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CONCRETE VALUE OF PHILIPPINE SAND, GRAVEL AND CRUSHED STONE

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FOUR TEXT FIGURES

INTRODUCTION

In view of the constantly increasing volume of concrete construction work in the Philippine Islands, greater interest is now felt in and more attention paid by engineers and contractors engaged in concrete work to the quantity and quality of the sand, gravel, and stone deposits of the country. Systematic and reliable data on the possible extent of these natural deposits, and the comparative concrete value of the materials will no doubt be of interest.

CONCRETE MATERIALS

Concrete is essentially made up of cement, sand, gravel or crushed stone (or mixtures of both), and water with which the materials are thoroughly incorporated. Its most important constituent is cement, ordinarily Portland or natural cement. In the Philippine Islands, Portland cement is exclusively used on all concrete construction work, and its efficiency as binding material is determined according to Circular 33 of the United States Bureau of Standards. Next in importance is sand.

Sand[1] in its commonly accepted sense, is a fine aggregate derived from a natural source, all of which will pass, when dry, a screen having circular opening ¼ inch in diameter.

[1] Proc. Am. Soc. of Testing Materials 20 (1920) 137.

In the Philippine Islands, sand deposits are ordinarily found at the seashore and in river beds. Rocks can be quarried and crushed by mechanical means, and all particles that pass through ¼-inch openings can be considered sand. The use of this material in actual practice, however, has been very limited; in some cases it is only used as a substitute for a portion of the natural sand.

Gravel is defined by Dake [2] as "any aggregate of rock particles, coarser than sand and finer than boulders."

In concrete construction work this definition would be incomplete unless the size of the pebbles were specified. It is common engineering practice to limit the maximum size of the broken stone or gravel to 2.5 inches.[3] Furthermore, in selecting the size of stone or gravel, various factors must be taken into consideration; such as thickness of the concrete section, proximity to the reënforcements, size and spacing of the reënforcements, etc. Reid [4] states the following:

> In reinforced concrete, the broken stone or screened gravel for the concrete surrounding the reinforcement ought never be larger than will pass a ½ inch screen when the reinforcement is small, or spaced close together or when placed near the surface. When larger sections are employed the stone may be increased in size, but should not exceed what will pass a 1¼ inch screen.

Broken stone, as its name indicates, is the product obtained by mechanical crushing of rocks or bowlders.

It used to be a common belief among practicing engineers that broken stone produces better concrete than does gravel, owing to the angular shape of the individual fragments. In this connection it is interesting to note the comparative crushing strengths given below of basaltic broken stone of good quality from Talim Island, Rizal Province, and two samples of gravel, one dark brown diorite from Pasig River, Rizal Province, and the other of a basaltic nature from Santa Cruz, Laguna Province.

Specimen.	Crushing strength, in pounds per square inch.
Gravel, from Santa Cruz, Laguna Province	3,027
Stone, from Talim Island, Rizal Province	2,834
Gravel, from Pasig River, Rizal Province	2,404

[2] The sand and Gravel Resources of Missouri, Missouri Bureau of Geology and Mines II 15 (1918) 1.

[3] Taylor, F. W., and E. S. Thomson, Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 13.

[4] Concrete and Reinforced Concrete Construction, New York, The Myron C. Clark Publishing Co. (1907) 44.

The proportion of the mixture in each case was 1 : 2 : 4 by volume, and the sand used, although from different sources, was of basaltic and andesitic origin of similar granulometric composition.

It is also interesting to note the seemingly conflicting opinions of certain authorities on this matter.

Taylor and Thomson [5] say:

> Comparative tests of concrete made with broken stone and with gravel, in the same proportions by volume, show almost always that concrete made from hard broken stone, such as trap, gives higher compressive strength than concrete made from gravel. This appears to be the rule, not only when the materials are mixed by measured volumes, regardless of the percentages of void, but also when the broken stone and gravel are each screened to substantially the same size.

Reid,[6] on the other hand, expresses himself in the following words:

> There is no ground for believing that rounded stone or rounded sand gives less strength with cement than materials composed of angular fragments.

The results shown above and the apparent conflicting opinions of authorities on the subject seem to lead to the conclusion that both gravel and broken stone have certain advantages and disadvantages. Gravel, on account of its rounded form, readily slips into place in concrete, thus reducing the volume to a minimum and forming a compact mass of higher density. On the other hand, the rough surface of the broken stone usually causes greater adhesive strength to develop than does the smooth surface of the gravel, which to a certain extent counterbalances the porosity and the relative lower density of the broken-stone concrete. Accordingly, a good hard and dense gravel is perfectly comparable as concrete material with a good broken stone and vice versa; and, if a poor gravel and a good broken stone are both available in a locality, they should be mixed in such proportion as to improve the concrete value of the former. As a matter of fact, a mixture of equal parts of Pasig River gravel and Talim Island broken stone was used in the construction of the Legislative Building in Manila.

[5] Concrete, Plain and Reinforced, 1st ed., New York, John Wiley and Sons (1905) 271–272; 3d ed. (1916) 324.

[6] Concrete and Reinforced Concrete Construction, New York, The Myron C. Clark Publishing Co. (1907) 43.

PREVIOUS WORK ON PHILIPPINE AGGREGATES

In 1909, Adams [7] published an article on the sources and the nature of the sand, gravel, and stone deposits near the City of Manila. The granulometric composition and the relative strengths of a few specimens were briefly discussed. The testing of the materials was incomplete; but, as Adams stated, "is sufficient to show their relative efficiencies and to check the conclusions arrived at from the geologic examinations." So, the main object of the author was the study of the aggregates, from the geologic point of view.

A more extensive work was published by Reibling [8] in 1910. At that time concrete construction in the Philippine Islands was not so highly developed as it is at present. As a matter of fact, in 1909, while Reibling's investigation was being carried out, only one hundred specimens of cement aggregate and concrete were submitted for test. Some of the results given were not reliable, in as much as the specimens tested were not prepared under the direct supervision of the Bureau of Science, but under the direction of the men in charge of the various construction works; for which reason, the much spoken of "human factor" was very much in evidence. In this connection, Reibling himself made the following statements:

> Concrete cubes tested as per "Request No. 68328" gave erratic results which were attributed to excess of sand and to the poor grading of the gravel. * * *.[9]
>
> At another time, laboratory and field tests did not agree. * * * [10]
>
> The facts above mentioned show the necessity of proper representative sampling and a uniform method for the treatment of concrete samples after they have been gauged. The same concrete preserved under different conditions will give variable results.

OBJECT OF THE PRESENT ARTICLE

In this article, all the routine tests on sand, gravel, and stone specimens made in the cement laboratory of the Bureau of Science, covering a period of more than fifteen years, are discussed from both the theoretical and the practical points of view. The samples were collected by engineers and contractors and forwarded to the laboratory to be tested. The results

[7] Philip. Journ. Sci. § A 4 (1909) 463.
[8] Philip. Journ. Sci. § A 5 (1910) 117.
[9] Ibid. 129.
[10] Ibid. 133.

served as the basis for judging the quality of the materials for construction purposes. It is a compilation of the most reliable data so far published on Philippine aggregates.

METHODS OF PROCEDURE

It is an accepted principle that the strength of concrete is mainly due to the following factors, namely:[11] The quality and quantity of cement; the kind, size, and strength of the aggregates; the thoroughness with which the ingredients are balanced; the method of mixing; and its age. Variation in any of these factors will no doubt influence the strength of the concrete.

In order to secure results that would be comparable with each other, uniform methods of procedure were adopted. Only cement of good quality was used; the same proportional quantity was mixed with the sand and gravel samples; the ingredients were thoroughly balanced; fixed methods of gauging, mixing, and moulding were followed; and the moulded concrete specimens were invariably tested at the age of twenty-eight days. So the only variable factor was that which has reference to the quality of the aggregates.

According to Taylor and Thomson,[12]

> There are two fundamental laws of strength which apply to mortars and concrete composed of the same cement with different proportion and sizes of sand and gravel.
>
> (1) With the same aggregate, the strongest and most impermeable mortar is that containing the largest percentage of cement in a given volume of the mortar.
>
> (2) With the same percentage of cement in a given volume of mortar, the strongest, and usually the most impermeable, mortar is that which has the greatest density, that is, which in a unit volume has the largest percentage of solid materials.

The first of these laws is understood by ordinary users of cement, but the second states a fact which is appreciated only by experts.

It is in connection with the second law that different authorities on concrete have made exhaustive studies, have written volumes of their experiences, and have even developed formulæ

[11] Reid, H. A., Concrete and Reinforced Concrete Construction, New York, The Myron C. Clark Publishing Co. (1907) 185. Similar factors are given by F. W. Taylor and S. E. Thomson, Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 310.

[12] Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 144.

and rules tending to reduce the pore space to a minimum to obtain the largest percentage of solid material per unit volume of concrete. The greatest handicap to the general practical application of these rules and formulæ is the large variety of materials that come under the denomination of aggregates.

The quality of the aggregates depends mainly upon three factors; namely, the geologic character of the rocks from which they are derived, the degree of chemical weathering, and the

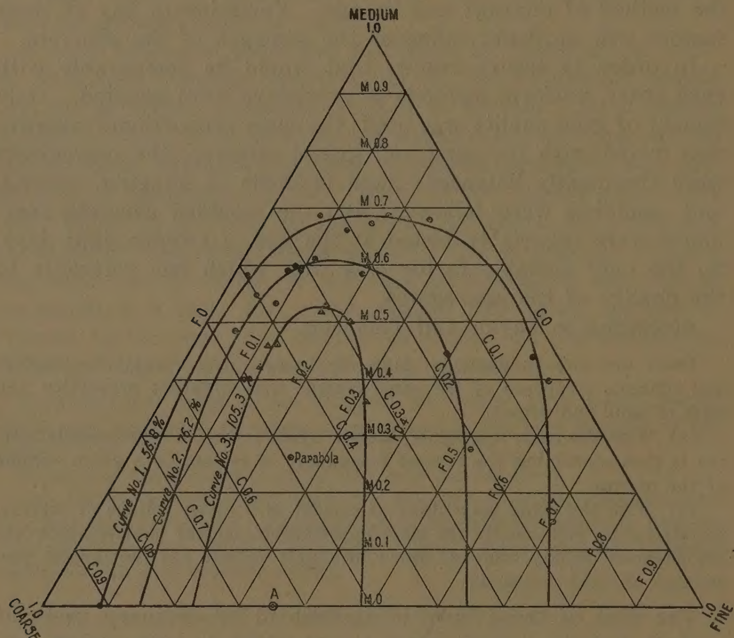

Fig. 1. Tensile-strength curves computed on the basis of the tensile strength of standard Ottawa sand as 100 per cent.

granulometric composition. It is not within human power to change the geologic character and the degree of chemical weathering of any sand or gravel deposit; but the granulometric composition can be so adjusted as to obtain arbitrarily graded particles which, when mixed with cement, will produce mortar and concrete of the greatest density, containing the largest percentage of solid material per unit volume.

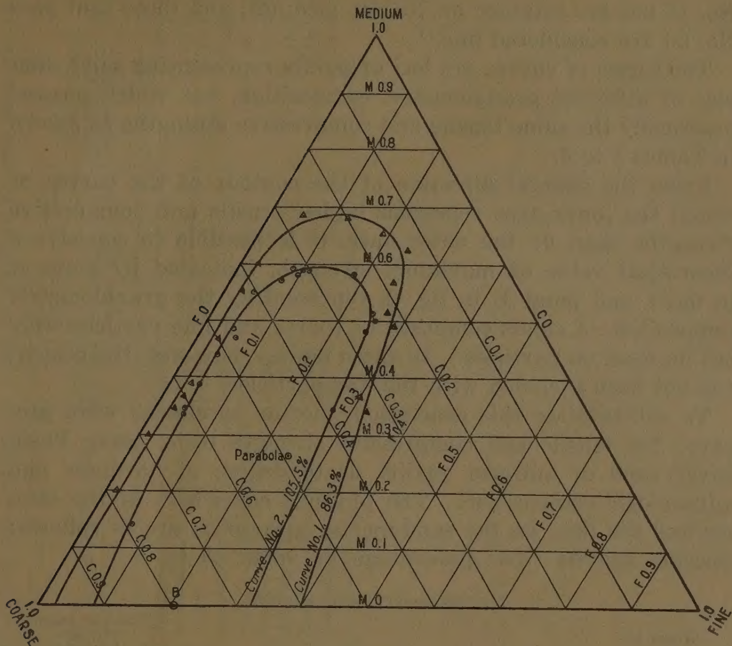

Fig. 2. Compressive-strength curves computed on the basis of the compressive strength of standard Ottawa sand as 100 per cent.

Feret, as long ago as 1892, after having made an extensive study on the mortar value of sand, arrived at the following conclusion:

> The plastic mortars, which per unit volume, contain the greatest absolute volume of solid materials (cement + sand) are those in which there are no medium grains, and in which coarse grains are found in proportion double to that of fine grains, cement included.[13]

How much practical truth there is in this statement is illustrated in figs. 1 and 2. Each triangle represents Feret's [14] three-screen method of granulometric sand analysis and each point shows the granulometric composition of a sand specimen. All sand particles that pass through a 0.2-inch opening but are retained on No. 15 mesh are considered coarse; those that pass

[13] Ibid. (1905) 147; (1916) 161.
[14] Ibid. (1905) 145–156; (1916) 159–160.

No. 15 but are retained on No. 50, medium; and those that pass No. 50 are considered fine.[15]

The series of curves are loci of points representing sand samples of different granulometric composition, but which possess practically the same tensile and compressive strengths as shown in Tables 1 to 5.

From the general direction of the contour of the curves of which the inner ones represent higher tensile and compressive strengths than do the outer ones, it is possible to conceive a theoretical value of maximum strength, indicated by point A in fig. 1 and point B in fig. 2, representing the granulometric composition of sands composed of coarse and fine particles only but no medium particles. In these figures, however, the cement has not been included with the fine particles.

To substantiate this conclusion, mortar specimens were prepared for tensile and compressive strength tests, using Pasig River sand of uniform quality as to degree of hardness and mineralogic composition. The physical characters of the sample and the data on the sand-mortar specimens are as follows: Specific gravity, 2.5; percentage of voids, 29.6.

Granulometric composition.

Screen No.	Particles passing through. Per cent.
4	100
10	58
20	32
30	18
40	10
50	6
80	4
100	3
200	2

[15] The sieves used conform with the United States Bureau of Standard specifications as published in Proc. Am. Soc. of Testing Materials I 24 (1924) 719:

Commercial No. of sieve.	Size of openings. Inch.	Size of openings. mm.
10	0.0787	1.999
20	0.0331	0.841
30	0.0232	0.589
40	0.0165	0.419
50	0.0117	0.297
60	0.0098	0.249
80	0.0070	0.178
100	0.0059	0.149
200	0.0029	0.074

TABLE 1.—*Sand specimens having an average tensile strength of 56.8 per cent on the basis of standard Ottawa sand as 100.*

Province.	Town.	Location of deposit.	Geologic classification.	Laboratory No.	Three-screen analysis.			Tensile strength. $\frac{\text{Sand specimen}}{\text{Ottawa sand}} \times 100.$
					Coarse.	Medium.	Fine.	
Batangas	San Luis	Beach	Volcanic sand	146593	4	40	56	57.4
Benguet	Baguio	Government Center	Mostly silica	150866	15	15	70	58.0
Bohol	Palo	Seashore	Mostly quartz	145397	3	44	53	57.7
Bulacan	Pulilan	Pulilan River	Basic volcanic rock	144591	7	69	24	55.0
Cavite	General Trias	Malabon River	Vesicular lava and some quartz	151029	14	69	17	59.4
Leyte	Palo	Malirong River	Basaltic sand	147651	16	68	16	59.0
Masbate	Milagros	Lumbang River	Andesitic and basaltic	149505	25	68	7	55.5
Mindanao	Jolo	Caldera Bay	Basaltic and some quartz	148237	40	58	2	55.6
Occidental Negros	Isabela	Binalbagan River	Andesitic and basaltic	153663	21	66	13	54.0

TABLE 2.—*Sand specimens having an average tensile strength of 76.2 per cent on the basis of standard Ottawa sand as 100.*

Province.	Town.	Location of deposit.	Geologic classification.	Laboratory No.	Three-screen analysis.			Tensile strength. $\frac{\text{Sand specimen}}{\text{Ottawa sand}} \times 100.$
					Coarse.	Medium.	Fine.	
Albay	Camalig	Cabraran River	Basaltic and andesitic	119543	23	58	19	76.0
Antique	Ipil	Bungul River	Andesitic	120133	21	60	19	71.8
Batangas	Santo Tomas	Tanawan River	Basaltic	147007	28	61	11	75.3
Bohol	Calape	Talisay shore	Andesitic	145445	16	46	38	72.8
Cavite	Kawit	Rio Grande	Igneous sand	122314	56	36	8	79.5
Do	Noveleta	Noveleta River	Basaltic	149506	40	55	5	78.0
Cebu	Daan Bantayan	Beach	Coralline	143761	33	59	8	73.0
Do	Poro	do	do	154356	34	59	7	78.0
Laguna	Santa Cruz	Malunod River	Basaltic	142380	32	59	9	78.0
Leyte	Tabontabon		Magnetite and quartz	121416	21	27	52	78.0
Oriental Negros	Bais	Bais River	Coralline	122046	38	53	9	77.7
Tayabas	Tayabas	Alitao River	Basaltic and andesitic	152450	47	48	5	77.0

TABLE 3.—*Sand specimens having an average tensile strength of 105.3 per cent on the basis of standard Ottawa sand as 100.*

Province	Town.	Location of deposit.	Geologic classification.	Laboratory No.	Three-screen analysis.			Tensile strength. $\frac{\text{Sand specimen}}{\text{Ottawa sand}} \times 100.$
					Coarse.	Medium.	Fine.	
Cebu	Carcar	Mananga River	Basaltic	147129	28	50	22	110
Laguna	San Pablo	Bañadero River	Andesitic, diorite	142608	30	53	17	105
Mindanao	Jolo	Baliwasan beach	Basaltic and coralline	148237	46	42	12	100
Do	Zamboanga		do	127041	32	52	16	107
Romblon	Romblon	Seashore	Coralline	144383	34	34	32	104
Samar	Borongan	Sunco beach	Andesitic basaltic	151148	41	46	13	100
Tayabas	Sariaya	Munting River	Basaltic	125700	43	46	11	111

TABLE 4.—*Sand specimens having an average compressive strength of 86.3 per cent on the basis of standard Ottawa sand as 100.*

Province.	Town.	Location of deposit.	Geologic classification.	Laboratory No.	Three-screen analysis.			Compressive strength. $\frac{\text{Sand specimen}}{\text{Ottawa sand}} \times 100$
					Coarse.	Medium.	Fine.	
Bataan	Orani	Orani River	Andesitic	145278	19	58	23	80.7
Batangas	Bauang	Bauang River	Basaltic	150352	62	34	4	90.4
Bulacan	Calumpit	Calumpit River	Volcanic rock	144857	27	68	5	87.0
Cavite	Kawit	Imus River	Mostly basalt and scoria	122314	78	20	2	87.0
Do	do	Rio Grande	Partially weathered volcanic rock	123443	58	38	4	88.6
Do	do	do	Volcanic	123521	60	36	4	89.5
Do	Noveleta	San Juan River	Scoriaceous basalt	125977	68	30	2	84.0
Cebu	Pinamugahan	Beach	Mostly quartz	144970	37	60	3	82.6
Ilocos Sur	Candon	Santa Cruz River	Andesitic and basaltic	151978	16	65	19	80.0
Iloilo	San Miguel	Aganao River	Magnetite and quartz	144037	23	52	25	86.0
Laguna	Pagsanjan	Pagsanjan River	Basaltic rocks	128903	43	54	3	87.1
Do	Santa Cruz	Santa Cruz River	Basaltic and andesitic	149829	50	46	4	89.5
Leyte	Alang-Alang	Dap-Dap River	Basaltic and magnetite	147651 A	23	49	28	85.7
Do	Dagani	Guinarona River	Basaltic rocks	147651 B	34	37	29	88.7
Pampanga	Magalang	Quitangil River	Volcanic	146671	13	63	24	86.8
Pangasinan	San Jacinto	San Jacinto River	Andesitic	145666	20	68	12	89.8
Romblon	Romblon	Seashore	Coralline	144383	34	34	32	84.0

TABLE 5.—*Sand specimens having an average compressive strength of 105.5 per cent on the basis of standard Ottawa sand as 100.*

Province.	Town.	Location of deposit.	Geologic classification.	Laboratory No.	Three-screen analysis.			Compressive strength. $\frac{\text{Sand specimen}}{\text{Ottawa sand}} \times 100.$
					Coarse.	Medium.	Fine.	
Albay	Malinao	Quilani River	Volcanic	119707	33	57	10	105
Antique	Ipil	Ipil River	Andesitic	120133B	38	35	27	110
Do	Sibalom	Sibalom River	Andesitic and basaltic	151980	37	56	7	103
Do	Valderrama	Caranagan River	Mostly andesitic	120133C	27	48	25	108
Cebu	Cebu	Guadalupe River	Andesitic	144671	61	34	5	101
Do	do	Guadalupe	Basic volcanic rocks	145880	31	58	11	106
Ilocos Norte	Vintar	Laoag River	Andesitic and basaltic	151190	52	43	5	109
Iloilo	San Miguel	Oton beach	Basaltic dioritic	145780	24	51	25	102
Laguna	Los Baños	Laguna de Bay at Bayog.	Basaltic	86085A	41	54	5	105
Do	do	Laguna de Bay at Mayondon.	do	86085B	48	46	6	100
Mindanao	Zamboanga	Tumaga River	Basaltic andesitic	122303B	79	14	7	107
Occidental Negros	Maao	Maragandang River	Andesitic	150748	24	50	26	106
Rizal	McKinley	Pasig River	do	145643C	25	58	17	100
Do	do	do	do	145643D	32	58	10	103
Do	Pasig	do	Basaltic and andesitic	154012	57	38	5	109
Sorsogon	Sorsogon	Lantu River	Andesitic and dioritic	154358	34	58	8	108
Tarlac	Capaz	Santiago River	Volcanic rock and quartz	123447	62	33	5	108
Tayabas	Tayabas	Alitao River	Basaltic and andesitic	152450	47	48	5	109

SAND-MORTAR SPECIMENS

S_1—A portion of the sample of sand was made into test specimens as received.

S_2—Another portion was screened into sizes of the following granulometric composition: 63 per cent passing No. 4 screen (about 0.2-inch opening) but retained on No. 15 screen, and the rest, 37 per cent, passing No. 50 screen. According to the Feret three-screen method of sand analysis, this specimen is composed of coarse and fine particles only and no medium particles.

S_3—A third portion was screened into several parts according to sizes, and the proportional quantities so obtained were adjusted to form a combined specimen having a well-graded granulometric composition curve similar to a parabola.

Test specimens using standard Ottawa sand were also prepared for purposes of comparison. The results are shown in Table 6.

TABLE 6.—*Influence of the granulometric composition of sands upon the strength of mortars.*

[Age of test specimens, 28 days.]

Item.	Proportion by weight.	Per cent granulometric analysis on the basis of Feret's three-screen method.			Weight of mortars at test in pounds per cubic foot.[a]	Per cent water of the dry mixture by weight.	Per cent void of the dry sand.	Average strength in pounds per square inch.	
		Coarse.	Medium.	Fine.				Tensile.[a]	Compressive.[a]
Ottawa	1 : 3	0	100	0	146	13.0	34.4	433	3,718
S_1	1 : 3	57	37	6	153	13.1	29.6	452	4,762
S_2	1 : 3	63	0	37	151	13.5	32.9	487	4,902
S_3	1 : 3	48	24	28	148	13.3	30.5	422	4,092

[a] The figures represent the average weight and strength of sixteen specimens.

The conclusion arrived at, that the theoretical points A and B (figs. 1 and 2), like those of Feret, are points of maximum strength, has been substantiated in this particular case. It should be noted, however, that mortar specimens under item S_1, which were prepared from the sample of sand as received, appear to be denser and nearly as strong as those under item S_2, which were prepared from sand composed of coarse and fine particles only. Mortar specimens under item S_3 appear to possess lower strength and lower density than do those under items S_1 and S_2, indicating that the parabola is not the ideal granulometric composition curve of a sand of the highest density and strength.

Generalizing the results of tests shown in Table 8, wherein the strengths of sand mortars composed of sand of widely different geologic characters and variable granulometric composition are compared with the strength of standard Ottawa sand mortar (considering the latter as 100), it is possible to arrive at another conclusion somewhat different from that of Feret.

In fig. 3, two curves were drawn; namely, curve 1 and curve 2. Each point in curve 1 represents the average percentage of coarse particles of the sand specimens shown in Table 8, corresponding to a given compressive strength. Similarly, each point in curve 2 represents the corresponding percentage of

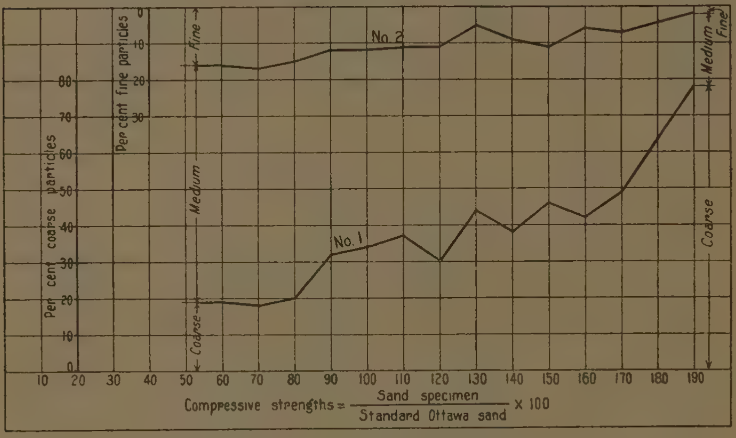

FIG. 3. Relation between compressive strength and the percentage of coarse, medium, and fine particles, representing the granulometric composition of sands.

fine particles of the same sand specimens. The vertical distance between the two curves represents the percentage of medium particles. Curve 1 may also be considered as the line of demarcation between the coarse and the medium particles, and curve 2, the line of demarcation between the medium and the fine particles.

It is apparent from the general direction of the curves that, as the comparative compressive strength increases, the proportion of coarse particles also increases, while the proportion of medium and fine particles decreases to a minimum. The general results, therefore, seem to point to the conclusion that

the theoretical point of maximum strength represents a uniformly graded sand composed of coarse particles with practically no fine and with the smallest amount of medium particles. In other words, sand mortars possessing exceptionally high strength are composed almost entirely of coarse sand and cement. Coarse sand is understood to be all particles that pass through a 0.2-inch opening and are retained on No. 15 mesh.

Between this conclusion and Feret's certain similarities and differences are observed; namely, both admit that the point of maximum strength represents the granulometric composition of a mortar composed of coarse and fine particles only, cement included, without medium particles. Feret's conclusion, however, admits of fine particles of sand with cement, while that drawn from fig. 3 does not admit of fine particles of sand, the cement taking its place entirely. Both conclusions appear to be applicable to sands of widely different geologic nature.

CONCRETE

In reference to the application to concrete of the second law of strength the results obtained by William B. Fuller [16] from a series of tests made in this connection, compared with the general results of tests shown in Table 9, are of interest. Fuller's [17] original theory was stated as follows:

> The experience which the writer has had and the various experiments which he has made indicate that concrete which works the smoothest in placing and gives the highest breaking strength for a given percentage of cement is made from an aggregate whose mechanical analysis taken after mixing the sand and the stone forms a curve approaching that of a parabola, with its beginning at zero coördinates (o) and passing through the intersection of the curve of the coarsest stone with the 100% line, that is, passing through the upper end of the coarsest stone curve.

This conclusion is based upon the comparative transverse strengths of concrete beams. Although no definite relationship exists between transverse strength and compressive strength, yet for practical purposes either method of testing can be adopted for comparing the relative strength of different materials.

Later experiments performed by the same author indicate that the curve of maximum density and strength is more accu-

[16] Taylor, F. W., and S. E. Thomson, Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 192.

[17] Taylor, F. W., and S. E. Thomson, Concrete, Plain and Reinforced, 1st ed., New York, John Wiley and Sons (1905) 195.

rately defined as the combination of an ellipse and a straight line than as a parabola.[18]

The ellipse-straight-line combination curve, however, represents the granulometric composition of the mixture of sand, gravel or stone, including cement, while the parabolic curve,[19] as above stated, represents the mixture of sand and stone, excluding cement.

By generalizing the results of concrete tests shown in Table 9 (that is, taking average values of the mechanical analyses of the sand and gravel, arbitrarily grouped according to their compressive strength), tabulating the values so obtained, and plotting the mechanical analysis curves of the gravel, some interesting conclusions may be drawn.

In Table 7 under the last column the three-screen method of presenting the mechanical analyses of gravel, similar to that of Feret, has been adopted. This is a very convenient means of discussing the general results of the tests. The different arbitrary limiting values adopted for coarse, medium, and fine sizes are as follows:

Coarse sizes are those passing holes 3 inches in diameter and retained on holes of 1.5 inches; medium sizes are those passing holes 1.5 inches in diameter and retained on holes 0.67 inch; and fine sizes are those passing holes 0.67 inch in diameter and retained on holes 0.2 inch.[20]

[18] Taylor, F. W., and S. E. Thomson, Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 192–198.

[19] Taylor, F. W., and S. E. Thomson, Concrete, Plain and Reinforced, 1st ed., New York, John Wiley and Sons (1905) 194–209; 3d ed. (1916), Appendix I, 849–855.

Construction of the Parabola.

If D=Largest diameter of stone.

d=Any given diameter.

P=Per cent mixture smaller than any given diameter.

The equation of the parabola would be

$$d=\frac{P^2D}{10,000}$$

[20] Feret's limiting values are as follows: Coarse, passing holes of 6 centimeters (2.36 inches) diameter and retained by holes of 4 centimeters (1.57 inches) diameter; medium, passing holes of 4 centimeters (1.57 inches) diameter and retained by holes of 2 centimeters (0.79 inch) diameter; fine, passing holes of 2 centimeters (0.79 inch) diameter and retained by holes of 1 centimeter (0.39 inch).

TABLE 7.—*Relation between the compressive strength of concrete and the mechanical analysis of the aggregates.*

[C, course; M, medium; F, fine. Figures express percentage composition.]

No.	Strength, pounds per square inch, 28 days.	Three-screen granulometric composition of sand.			Mechanical analysis of gravels; per cent sizes passing through various circular openings; diameters in inches.			
		C	M	F	3.00	2.25	1.50	1.00
1	1,000–1,500	22.0	56.7	21.3	100	99.3	87.4	44.8
2	1,500–2,000	28.2	59.3	12.5	100	98.8	83.2	49.8
3	2,000–2,500	30.9	56.7	12.4	100	99.4	75.7	42.9
4	2,500–3,000	40.4	46.6	13.0	100	95.8	71.6	28.2
5	3,000–3,500	41.0	49.6	9.4	100	99.2	78.5	32.4

No.	Strength, pounds per square inch, 28 days	Mechanical analysis of gravels; per cent sizes passing through various circular openings, diameter in inches.					Three-screen method of mechanical analysis of gravel.		
		0.67	0.45	0.30	0.20	0.15	C	M	F
1	1,000–1,500	26.3	16.5	13.8	11.6	3.5	13	61	26
2	1,500–2,000	30.0	16.1	13.3	7.1	5.5	17	53	30
3	2,000–2,500	21.7	9.0	3.1	3.1	3.0	24	54	22
4	2,500–3,000	9.8	1.9	0.5	0.4	0.1	28	62	10
5	3,000–3,500	16.3	6.6	4.8	0.8	0.1	22	62	16

The results shown in Table 7 under the second column reaffirm the conclusion arrived at for sand; namely, the larger the quantity of coarse particles of a given specimen of sand, the higher its compressive strength, from which it naturally follows that coarse sand makes a good aggregate, both for mortar and for concrete.

From the average mechanical-analysis curves of gravels shown in fig. 4, the following general conclusion is apparent:

Gravels showing satisfactory compressive strengths are composed of not less than 22 per cent coarse sizes and not more than 22 per cent fine sizes, the rest consisting of medium sizes.

This conclusion appears to be satisfactorily applicable to Fuller's [21] ellipse-straight-line theory,[22] but it is not in accordance

[21] Taylor, F. W., and S. E. Thomson, Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 192–198.

[22] The straight line shown in fig. 4 corresponds to the proportional quantity of gravel present in Fuller's ellipse-straight-line curve, which includes cement, sand, and gravel.

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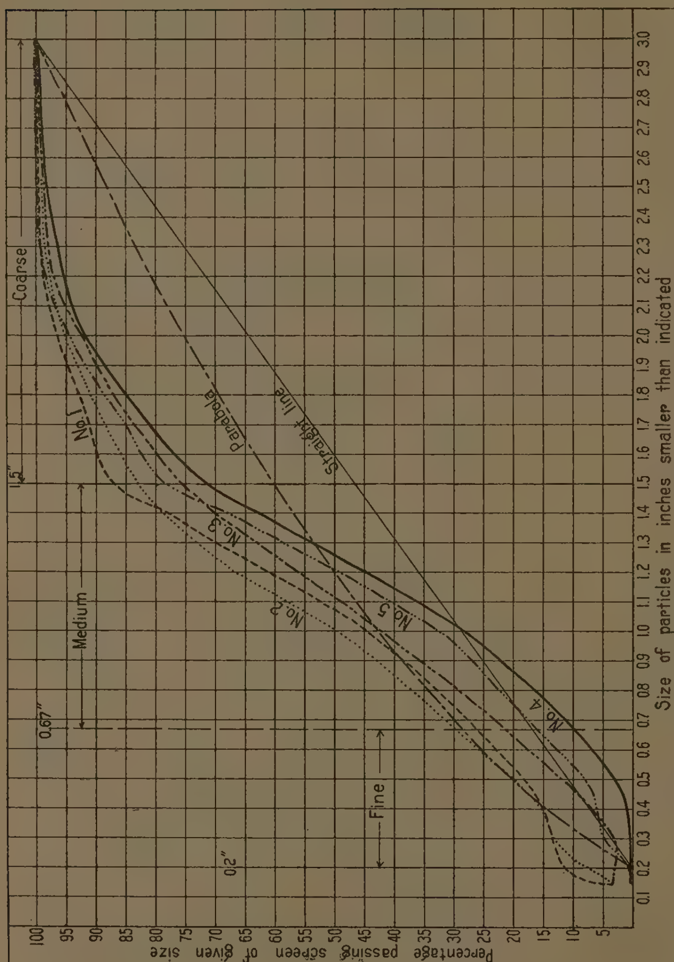

FIG. 4. Average mechanical analysis curves of gravels used in the testing of concrete specimens, grouped according to their compressive strengths as shown in Table 7.

with his parabolic curve.[23] The parabola in fig. 4 is above the 22 per cent limiting value for fine sizes of gravel; it consists of 40 per cent coarse sizes and 28.5 per cent fine sizes. The straight line, on the other hand, consists of 53.5 per cent coarse sizes and 17 per cent fine sizes.

In view of these results, it is safe to assume, for the time being, the practical truth of the following conclusion:

Under similar conditions of hardness and general geologic character, the nearer the mechanical-analysis curve of a gravel specimen approaches a straight line, the higher is the crushing strength of concrete made from this gravel; provided the cement used is of good quality and the sand is mainly composed of coarse particles with the smallest proportion of medium particles and with practically no fine particles.

RESULTS OF TESTS

The results of tests for sand and gravel are shown in Tables 8 and 9, respectively. They are grouped by provinces to facilitate the location of the deposits. Many of the specimens show low tensile and compressive strengths. Such materials were sent to the laboratory for comparative test only, but have not been actually used in construction work. The supervising engineers of the Bureau of Public Works have always taken the necessary precautions to see that a better grade of aggregates was used in all cases, oftentimes at great expense because of the cost of transporting adequate materials from the sources of supply to the site of the job.

In order that the tensile and compressive strengths of the various sands for seven and for twenty-eight days might be comparable with each other, independently of the variation in the quality of the cement used, they were compared with the tensile and compressive strengths of specimens made of the same cement and standard Ottawa sand on the basis of 100; the results shown in the last columns of Table 8 were computed in this manner.

The mixture for mortar was invariably in the proportion of 1 : 3 by weight for tensile and compressive strength; and for gravel 1 : 2 : 4 by volume, considering the weight of 1 cubic foot of cement to be 94 pounds. The form and size of the specimens for compressive strength were cubes 2 by 2 by 2

[23] The curve shown in fig. 4 is a portion of the parabola corresponding to the proportional quantity of gravel present in the mixture of sand and gravel.

inches and cylinders 3.54 by 7 inches for mortar, and 6 by 6 by 6 inches for concrete. Deviations from this method were noted.

The relation between the unit strength of sand mortars tested in the form of cubes and those tested in the form of cylinders cannot be precisely established; it has been found to be very variable. However, the following average compressive strengths of standard Ottawa sand mortar representing eighty-two cylinders and thirty-four cubes are given for purposes of information:

Age of specimens at test.	Compressive strengths in pounds per square inch.	
	Cylinders.	Cubes.
Days.		
7	1,656	1,762
28	2,468	3,134

The above results show that the cubes are 6.4 per cent stronger than the cylinders at the age of seven days, and 26.98 per cent stronger than the cylinders at the age of twenty-eight days.

It is apparent that the cubes attain their maximum strength much sooner than do the cylinders; as a matter of fact, the average increase in strength of the cylinders from seven to twenty-eight days is 49 per cent and that of the cubes, 78 per cent. The increase in strength varies, for cylinders, from 19 to 77 per cent; and for cubes, from 49 to 110 per cent.

According to Feret—[24]

> The form and dimensions of the specimen do not greatly influence the strength per unit area in compression when the height and width of the block are approximately equal.

In view of this conclusion, therefore, the above difference in the unit strength between cylinders and cubes should be attributed to the inequality of the width and height of the cylinders rather than to the difference in the size of the specimens tested, and cylindrical specimens having approximate dimensions of 7 inches in diameter by 7 inches in height would give nearly the same unit strength as the 2 by 2 by 2 inch specimens.

[24] Taylor, F. W., and S. E. Thomson, Concrete, Plain and Reinforced, 3d ed., New York, John Wiley and Sons (1916) 145.

All the tests shown in Tables 8 and 9 were performed in the cement laboratory of the Bureau of Science, under the direct supervision of W. C. Reibling, F. D. Reyes, A. W. King, and myself.

GENERAL GEOLOGIC CHARACTERS OF THE AGGREGATES

Most of the Philippine sands and gravels used for construction work are either andesitic or basaltic. This undoubtedly is due to the fact that nearly all the volcanic rocks of the Islands are andesitic, though basalts with variable amounts of olivine are also abundant.[25]

Sand and gravel containing relatively greater percentages of feldspar are found in the beds of rivers that flow through Pangasinan, Tarlac, and Zambales Provinces. Many of these rivers derive their water from the northeastern and southwestern sections of the western cordillera. According to Smith,[26] the main sources of sands of this kind are feldspar porphyry of the same character as the rocks that compose Mount Pinatubo.

Sand and gravel of calcareous nature, consisting mainly of coralline limestone, are found in large quantities in Cebu, Bohol, and Romblon Provinces. According to Becker,[27] Cebu is covered for the most part by a mantel of coral a hundred or more feet in thickness, which reaches from the crest of the island to the sea; Smith [28] believes that the geologic formations of Bohol are similar to those of Cebu. A great deal of the sand used in Romblon is taken from Tablas Island at sitio Bantayan; both islands are largely of limestone formation.[29]

The sand and gravel specimens from Cavite and Batangas are of a scoriaceous and tuffaceous nature, and show at a glance their volcanic origin. The rivers from which the materials were taken derive their waters from the mountains and ridges situated in the neighborhood of Taal Volcano, which are composed of volcanic ash and tuff deposits.[30]

[25] Iddings, J. P., Philip. Journ. Sci. § A 5 (1910) 155.

[26] Philip. Journ. Sci. § A 4 (1909) 22–23.

[27] Report on the Geology of the Philippine Islands (1901) 19.

[28] Geology and Mineral Resources of the Philippine Islands, Bur. Sci. Pub. 19 (1924) 195.

[29] Ibid. 200.

[30] Adams, G. I., Philip. Journ. Sci. § A 5 (1910) 95.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands.*

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
1	Albay	Camalig	Cabraran River	A	Guinobatan-Jovellar bridges.		119543	Dec. 7, 1924	Basaltic and andesitic.
2	Do.	Daraga	Yawa River	U	Albay High School	1.50	149637	Jan. 4, 1924	Sharp-grained volcanic.
3	Do.	Malinao	Quinali River				119707	Jan. 25, 1915	Volcanic.
4	Do.	Oas	Creek, Legaspi-Agus road, kilometer 32.	A	Oas School building	2.00	157832	July 6, 1925	Vesicular lava.
5	Do.	do.	Creek, Legaspi-Agus road, kilometer 36.	A	do.	2.50	157833	do.	Slightly weathered vesicular basalt.
6	Do.	do.	Quinali River	U	do.	1.50	157382	June 9, 1925	Scoriaceous sand.
7	Do.	Polangui	Polangui River	U	Boranguit Bridge	2.00	145626	Feb. 3, 1923	Basaltic.
8	Do.	do.	do.		Libon Bridge on Quinali River.		120494	July 3, 1915	Andesitic, basaltic.
9	Antique		Bungol River		Bungol River Bridge		120133A	May 7, 1915	Andesitic.
10	Do.	Ipil	Ipil River		do.		120133B	do.	Do.
11	Do.	Sibalom	Magranca beach	A	Sibalom-San José irrigation project.	1.00	154419A	Dec. 8, 1924	Andesitic and basaltic.
12	Do.	do.	do.	A	do.	1.00	154419B	do.	Do.
13	Do.	do.	Sibalom River	A	do.	1.00	152180A	Jan. 23, 1924	Do.
14	Do.	do.	do.	A	do.	1.00	152180B	do.	Do.
15	Do.	do.	do.	A	do.	1.00	151469	May 6, 1924	Do.
16	Do.	do.	do.	A	do.	1.00	151652	May 16, 1924	Do.
17	Do.	do.	do.	A	do.	1.00	151980	June 10, 1924	Andesitic and basaltic (washed).

18	Do	do	Timpuluan River	A	do	1.00	151981	do	Andesitic and basaltic (weathered).
19	Do	do	do	A	do	1.00	152179A	June 23, 1924	Andesiticand basaltic.
20	Do	do	do	A	do	1.00	152179B	do	Andesitic, basaltic, and magnetite.
21	Do	Valderrama	Caranagan River	A	Bungol River Bridge		120133C	May 7, 1915	Andesitic.
[illegible]	Bataan	Balanga	Talisay River	U	Balanga Elementary School.	1.50	158269	July 31, 1925	Basaltic and feldspar.
23	Do	Mariveles	Mariveles beach	A	Bureau of Navigation works.		117596	Oct. 2, 1913	Andesitic.
24	Do	Orani	Orani River		U. S. Army building		94269	Nov. 17, 1911	Quartz and feldspar.
25	Do	do	do	U	Orani market	2.00	144546	Nov. 11, 1922	Weathered dioritic.
26	Do	do	do	U	do	2.00	144935	Dec. 6, 1922	Weathered andesitic.
27	Do	do	Orani River (Mulawin).	U	do	4.00	145278A	Jan. 4, 1923	Andesitic.
[illegible]	Do	do	Patolo River	U	do	3.00	145278B	do	Do.
29	Do	do	Talisay River	U	do	6.00	145278C	do	Do.
30	Do	Orion	Araro River	U	Arellano Memorial School.	3.00	147304A	June 16, 1923	Feldspar.
31	Do	do	Orion River	U	do	2.50	147304B	do	Feldspar and basaltic.
32	Do	do	San Vicente River	U	do	2.50	147304C	do	Do.
33	Batangas	Batangas	Batangas beach	A	Batangas Provincial Capitol.		158598	Aug. 22, 1925	Volcanic tuff.
34	Do	do	Calumpang River	A	do		158266	July 31, 1925	Do.
35	Do	do	Lubiran River	A	do		158671	Aug. 27, 1925	Do.
36	Do	do	Sabang River	A	do		158610	Aug. 24, 1925	Do.
37	Do	Bauan	Bauan River	A	Bauan waterworks		150352	Feb. 25, 1924	Basaltic.
[illegible]	Do	Calaca	Lumbang River	A	Calaca municipal building.		158311	Aug. 4, 1925	Volcanic tuff.
39	Do	Rosario	Pañginsiñgan River	L	Rosario waterworks		159498	Oct. 21, 1925	Volcanic tuff, very much weathered.
40	Do	do	Tembol hill	L	do		158969	Sept. 16, 1925	Volcanic tuff.
41	Do	San Luis	San Luis beach	U	San Luis municipal building.	0.54	146593	Apr. 20, 1923	Volcanic.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
42	Batangas	Santo Tomas	Tanauan River	U	General Malvar Memorial School.		147007	May 24, 1923	Basaltic sand.
43	Do	Talisay	Talisay beach (Taal Lake).	A	Talisay waterworks		159123	Sept. 25, 1925	Volcanic tuff.
44	Benguet	Baguio	Engineers hill		Baguio public-works project.		150866A	Mar. 26, 1924	Chert.
45	Do	do	Government Center		do		150866B	do	Quartz.
46	Do	do	Limestone quarry				123024	Aug. 9, 1916	Limestone-rock screenings.
47	Do	Trinidad					110110A	Nov. 26, 1912	Sand from sedimentary and igneous rocks.
48	Do	do					110110B	Nov. 26, 1925	Altered andesite.
49	Bohol	Batuan	Batuan beach	U	Culverts	12.00	144207	Oct. 19, 1922	Shell and some quartz.
50	Do	Calape	Barrio Sijoton Creek	A	Calape water reservoir	3.00	157988	July 16, 1925	Hardened clay.
51	Do	do	Talisay seashore	U	Calape public buildings	2.50	145445	Jan. 18, 1923	Shell and coral.
52	Do	Colonia	Masing River (inland).	A	Bridges and culverts	1.00	145401	Jan. 13, 1923	Feldspar.
53	Do	Dauis	Magtubo beach	U	Dauis Bridge	0.90	146940	May 19, 1923	Coralline and shells.
54	Do	do	Mana-ol seashore	U	Bohol dispensary pavillion.	3.00	156615	Apr. 21, 1925	Do.
[illegible]	Do	do	Umpas Sunculan seashore.	U	do	3.00	156616	do	Do.

56	Do.	Dimiao	Tanguhay seashore	U	Miscellaneous public buildings.	2.00	145398	Jan. 13, 1923	Volcanic.
57	Do.	Duero	Duero seashore		Duero public works		127125	Feb. 19, 1918	Granite, sand and some shells.
58	Do.	do.	do.	U	Bridges and culverts	2.00	145399	Jan. 13, 1923	Volcanic rock.
59	Do.	Guindulman	Guindulman beach	U	Culverts	1.50	144889	Dec. 4, 1922	Volcanic rock, shell, and quartz.
60	Do.	do.	do.	U	Bridges and culverts	2.00	145400	Jan. 13, 1923	Decayed serpentine.
61	Do.	Jetafe	Jetafe seashore	U	Jetafe municipal building.	1.50	152172A	June 23, 1924	Coralline and quartz.
62	Do.	do.	do.	U	do.	1.50	152172B	do.	Coralline.
63	Do.	Loay	Loay River, 8 kilometers distant.		Loay waterworks	2.00	125375A	Sept. 19, 1917	Rounded quartz.
64	Do.	do.	Loay River, 14 kilometers distant.		do.		125375B	do.	Rounded coral.
65	Do.	do.	Loay River, 16 kilometers distant.	U	For use as sand blast	2.50	130432	June 11, 1919	Feldspar, some corals, and shells.
66	Do.	do.	Seashore, kilometer 25.	U	Laboc water reservoir	6.50	157257A	May 28, 1925	Coralline.
67	Do.	do.	do.	U	do.		157257B	do.	Do.
68	Do.	Maribojoc	Seashore at Punta Cruz.	U	Provincial Trade School.	6.00	155542	Feb. 21, 1921	Do.
69	Do.	Palo (Loay)	Seashore at Palo	U	Beacon bridges	2.00	145397	Jan. 13, 1923	Angular quartz.
70	Do.	Tagbilaran	Seashore at Dauis	U	Provincial High School	2.50	144208A	Oct. 19, 1922	Corals and shells.
71	Do.	do.	Seashore at Dauis (Manaol).	U	do.	2.50	144208B	do.	Do.
72	Do.	do.	Manaol beach near Beacon.	U	do.	2.50	144208C	do.	Do.
73	Do.	do.	Tagbilaran beach	U	do.	2.50	144208D	do.	Do.
74	Do.	do.	do.	U	do.	2.00	143950	Sept. 26, 1922	Do.
75	Do.	do.	Beach at mouth of creek.	U	Bohol dispensary pavillion.	7.00	156614	Apr. 21, 1925	Coralline.
76	Do.	Valencia	Valencia beach	U	Valencia barrio school	2.50	150416A	Feb. 28, 1924	Do.
77	Do.	do.	Mouth of Panangatan River.	U	do.	2.50	150416B	do.	Do.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
78	Bohol	Valencia	Valencia beach	U	Valencia barrio school	2.00	149877	Jan. 24, 1924	Coralline.
79	Bulacan	Angat	Angat River		Angat River dam		142811	June 3, 1922	Hard basalt and andesite.
80	Do	Bocaue			Bocaue Bridge		66785	Mar. 18, 1909	
81	Do	do	Bocaue River	A			121142A	Oct. 12, 1915	Basalt, magnetite, and quartz.
82	Do	do	do	A	Irrigation canal structures.		149420	Dec. 14, 1923	Basaltic and andesitic.
83	Do	do	do	A	Angat irrigation project.		155434	Feb. 14, 1925	Do.
84	Do	do	Bocaue River at bridge.	A	do		155545A	Feb. 21, 1925	Do.
85	Do	do	do	A	do		155545B	do	Do.
86	Do	do	do	A	do		155545C	do	Basaltic and andesitic (weathered).
87	Do	Bustos	Angat River		do		142996	June 21, 1922	Hard andesitic.
88	Do	Calumpit	Bagbag River		Malolos waterworks		145288A	Jan. 4, 1923	Basaltic.
89	Do	do	Calumpit River		do		144857	Dec. 1, 1922	Hard basalt and andesite.
90	Do	do	Pulilan River		do		145288B	Jan. 4, 1923	Basaltic, round-grained.
91	Do	do	Pulilan River at Tibag.		do		145288C	do	Basaltic, round-grained quartz.
92	Do	Hagonoy			Hagonoy market		110032	Nov. 23, 1912	Quartz and magnetite.
93	Do	do	Santo Niño River				121142B	Oct. 12, 1925	Basaltic and quartz.

94	Do.	Malolos			Malolos Trade School		62645	Nov. 25, 1908	
95	Do.	do	Paombong River		Malolos waterworks		144856	Dec. 1, 1922	Basaltic.
96	Do.	Pulilan	Pulilan River	A	Pulilan market		121142C	Oct. 12, 1915	Basaltic and quartz.
97	Do.	do	do	A	Malolos waterworks	2.50	144591	Nov. 15, 1922	Basic volcanic.
98	Do.	San Ildefonso	Ma-asim River		Bureau of Public Works project M211.		110874	Dec. 25, 1912	Andesite, hematite, and quartz.
99	Do.	Santa Maria	Santa Maria River		Santa Maria Bridge		125491	Oct. 13, 1917	Vesicular basalt.
100	Do.	San Miguel	San Miguel River	U	Bolo Bridge		113991	Apr. 28, 1913	
101	Do.	do	do	U	San Miguel Bridge	2.50	147908	Aug. 2, 1923	Basalt and andesite.
102	Cagayan	Aparri	Aparri beach	U	Aparri shore protection.	0.40	149619	Jan. 3, 1924	Basalt and feldspar.
103	Do.	do	Casabalangan, 42 kilometers from town.	U	do		151295	Apr. 23, 1924	Basalt and andesite.
104	Do.	do	Aparri beach	U	do	0.40	150666	Mar. 15, 1924	Basalt and quartz.
105	Do.	do	Santa Maria (Lallo)	A	do	3.50	151833	May 29, 1924	Basalt and andesite.
106	Camarines Norte.	Paracale	Tugos Creek		Paracale waterworks	3.00	158424	Aug. 11, 1925	Quartz.
107	Capiz	Capiz	Lawan and Capiz River junction.	U	Libas Bridge	1.25	121658	Dec. 29, 1915	Quartz, magnetite, olivine, and clay.
108	Do.	Dao	Panay River	U	Balucuan Bridge	1.75	121656	do	Basaltic.
109	Do.	Ioisan	Bar at Lawan-Capiz River.	U	Ioisan School	2.50	121434	Nov. 22, 1915	Quartz, hornblende, tuff, and basalt.
110	Cavite	General Trias	Malabon River	U	General Trias School	3.50	151029	Apr. 5, 1924	Vesicular lava and quartz.
111	Do.	Imus	Imus River				123445	Nov. 1, 1916	Soft volcanic scoria.
112	Do.	Indang	Mountain stream		Indang and Alfonso School.		122322	Apr. 27, 1916	Vesicular basalt.
113	Do.	Kawit	Imus River		Aguinaldo School		122314A	Apr. 28, 1916	Volcanic tuff and scoria.
114	Do.	do	Rio Grande		do		122314B	do	Volcanic.
115	Do.	do	do		Calero River Bridge		123443	Nov. 1, 1916	Do.
116	Do.	do	do				123521	Nov. 15, 1916	Ferromagnesian.
117	Do.	Noveleta	Noveleta River	U	Cavite waterworks	3.00	149506	Dec. 22, 1923	Basaltic.
118	Do.	do	San Juan River at bridge.		Noveleta-Cavite road		125977	Jan. 2, 1918	Scoriaceous basalt.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
119	Cavite	Ternate	River bed opposite town.		U. S. Military buildings		94269	Nov. 17, 1911	Scoria, pumice, and tuff.
120	Cebu	Argao	Argao beach	A	Concrete culverts		147975A	Aug. 11, 1923	Coralline.
121	Do	do	Argao River	A	do		147975B	do	Basaltic (screenings).
122	Do	Asturias	Asturias beach	A	Asturias School building.	3.00	146321	Mar. 31, 1923	Volcanic, quartz, and shells.
123	Do	Badian	Badian Island	U	Bridges and culverts	3.50	145190	Dec. 27, 1922	Corals and shells.
124	Do	Barili	Japitan beach	A	Barili School building	2.40	152599	July 24, 1924	Coralline.
125	Do	do	Stream, Barili south road, kilometer 115.8.		Barili south road		114329	May 8, 1913	
126	Do	Carcar	Mananga River	U	Carcar waterworks	2.40	147129	June 2, 1923	Weathered basalt.
127	Do	Catmon	Bau River bed	U	Miscelllaneous construction.		145879	Feb. 26, 1923	Angular volcanic.
128	Do	Cebu	Buhisan River		Dam, Osmeña waterworks.	1.00	152214	June 26, 1924	Basaltic, andesitic (weathered).
129	Do	do	Guadalupe River	U	Cebu Normal School	1.60	144671	Nov. 20, 1922	Volcanic scoria.
130	Do	do	do	U	do	2.20	145880	Feb. 26, 1923	Do.
131	Do	do	Mananga River				78560	May 16, 1910	
132	Do	do	do				123328	Oct. 7, 1916	Derived from sedimentary rocks.
133	Do	Daan Bantayan	Town beach	A	Tank		143761	Sept. 8, 1922	Corals and shells.
134	Do	do	Bogo beach	A	do		144247	Oct. 21, 1922	Do.

135	Do	Dalaguete Alcoy.	Beach near cemetery.	A	Culverts		147399	June 21, 1923	Calcareous.
136	Do	Danao	Danao River				78560	May 16, 1910	
137	Do	Dumanjug	Dumanjug beach	A	Dumanjug School	1.40	144888	Dec. 4, 1922	Corals and shells.
138	Do	Liloan	Liloan beach	A	Cebu public works		146141	Mar. 16, 1923	Hard basalt and quartz.
139	Do	Mandawe	Mandawe beach				123327	Oct. 7, 1916	Quartz.
140	Do	Opon	Butuanon River at Mandawe.	A	Mactan School	3.50	155075	Jan. 15, 1925	Andesitic and basaltic.
141	Do	Pinamugahan	Pinamugahan beach	U	Miscellaneous public works.	1.20	144970	Dec. 8, 1922	Angular quartz.
142	Do	Poro	Poro beach	A	Poro municipal building.		154356	Dec. 4, 1924	Coralline.
143	Do	San Remigio	San Remigio River	A	San Remigio municipal building.		139931	Aug. 31, 1921	Corals and shells.
144	Do	Santander	Beach at mouth of creek.	A	Santander municipal building.	1.00	156037	Mar. 19, 1925	Coralline.
145	Do	Toledo	Tajao River				122395	May 12, 1916	Basalt, shells, and corals.
146	Ilocos Norte	Laoag	Laoag River bed		Road and bridges		121023	Sept. 22, 1915	Andesite, diorite, and quartz.
147	Do	do	Laoag River bank	A	Laoag Normal School	1.20	149318	Dec. 6, 1923	Andesite and quartz.
148	Do	Vintar	Vintar River at dam	A	Laoag-Vintar irrigation project.	1.40	150853	Mar. 25, 1924	Weathered andesite and basalt.
149	Do	do	do	A	do		151190	Apr. 15, 1924	Andesite, basalt, and quartz.
150	Ilocos Sur	Candon	Santa Cruz River bed.	U	Candon School	3.00	151978	June 10, 1924	Do.
151	Do	Vigan	Govantes River bed	U	Provincial Hospital	2.00	151331A	Apr. 25, 1924	Basaltic.
152	Do	do	Govantes River bed (washed).	U	do	4.50	151885	June 3, 1924	Andesitic, basaltic, and quartz.
153	Do	do	Mestizo River	U	do	2.00	151331B	Apr. 25, 1924	Basaltic.
154	Iloilo	Iloilo	Jaro River	U	Iloilo Normal School	2.50	154417	Dec. 8, 1924	Basaltic, feldspar, and quartz.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
155	Iloilo	La Paz			Iloilo Provincial Prison		88922	June 14, 1911	
156	Do	Molo			Molo Bridge		84978	Dec. 9, 1910	
157	Do	San Miguel	Aganao River		Aganao irrigation project.		142721	May 25, 1922	Andesite, basalt, and quartz.
158	Do	do	do	A	do	1.50	144037	Oct. 3, 1922	Magnetite and quartz.
159	Do	do	Oton beach	A	do	1.00	145780	Feb. 17, 1923	Basalt and diorite.
160	Do	Santa Barbara	Santa Barbara River.	U	Bainica River bridge	2.84	155603	Feb. 26, 1925	Basalt, andesite, and limestone.
161	Do	do	do	U	Capiz Elementary School.	2.84	159394	Oct. 14, 1925	Andesite and basalt.
162	Laguna	Bay	Bay River		Culverts		145378	Jan. 12, 1923	Do.
163	Do	Los Baños	Bayog, near lake	A	Miscellaneous buildings		86085A	Jan. 26, 1911	Do.
164	Do	do	Bay River	U	do		130307	May 22, 1919	Volcanic tuff and scoria.
165	Do	do	Los Baños Bay	A			139310	July 18, 1921	
166	Do	do	Mayondon No. 1	U	Miscellaneous improvements.		86085B	Jan. 26, 1911	Basalt and shells.
167	Do	do	Mayondon No. 2, 100 meters from No. 1.	U	do		86085C	do	Do.
168	Do	Majayjay	Majayjay River	A	Majayjay waterworks		132068	Dec. 6, 1919	Andesite and basalt.
169	Do	do	Olla River	U	Majayjay market		158671	Aug. 27, 1925	Oxidized argillaceous matter.

170	Do.	Pagsanjan	Pagsanjan River		Pagsanjan waterworks		128903	Dec. 6, 1918	Angular basaltic sand.
171	Do.	Rizal	Mayton River	U	Rizal School		143644	Aug. 29, 1922	Scoriaceous basalt.
172	Do.	do.	do.	U	do.		145733	Feb. 14, 1923	Do.
173	Do.	Santa Cruz	Malunod River		Bañadero River Bridge		142380	Apr. 20, 1922	Weathered basaltic sand.
174	Do.	do.	Santa Cruz River	A	Santa Cruz Hospital		149829	Jan. 21, 1924	Basaltic and andesitic.
175	Do.	San Pablo	Bañadero River	A	Bañadero River Bridge		142608	May 12, 1922	Andesitic dioritic.
176	Do.	do.	Lucena beach		do.		142926	June 16, 1922	Do.
177	Leyte	Alangalang	Dapdap River		Provincial public works		147651A	July 11, 1923	Basaltic and magnetite.
178	Do.	do.	Lingayon River		do.		147651B	do.	Weathered basaltic sand.
179	Do.	Barugo	Tunga River		do.		147651C	do.	Do.
180	Do.	do.	Barugo beach		Barugo School		121025	Sept. 22, 1915	Basaltic.
181	Do.	Bato	Bato beach				120782	Aug. 12, 1915	Quartz, ferromagnesian, and shells.
182	Do.	Burauen	Burauen River		Provincial public works		147651D	July 11, 1923	Basalt and quartz.
183	Do.	Carigara	Carigara River	U	Carigara School		145326	Jan. 8, 1923	Volcanic.
184	Do.	Dagami	Guinarona River		Provincial public works		147651E	July 11, 1923	Fairly hard basaltic.
185	Do.	Dulag	Tibuc River		do.		147651F	do.	Weathered basalt.
186	Do.	Magelian	Triana beach	U	Limasawa School		149996	Feb. 1, 1924	Coralline.
187	Do.	Ormoc	Anilao River	U	Ormoc market	1.50	159886	Nov. 11, 1925	Basalt and andesite.
188	Do.	Palo	Malirong River		Provincial public works		147651G	July 11, 1923	Basaltic (weathered).
189	Do.	Pastrana	Calogcog River		do.		147651H	do.	Coarse basalt.
190	Do.	Tabontabon			Tabontabon School		121416	Nov. 24, 1915	Magnetite, quartz, and pyroxene.
191	Do.	Tacloban	Beach, kilometer 4, Tacloban-Carigara road.		Tacloban wharf	2.00	150161A	Feb. 12, 1924	Andesite, a little quartz, and shells.
192	Do.	do.	Beach, kilometer 5, Tacloban-Carigara road.	U	For use as sand blast	2.20	130434	June 12, 1919	Andesite and trachyte.
193	Do.	do.	Camp Bampuo	U	Tacloban wharf	0.75	146284A	Mar. 27, 1923	Quartz, corals, and shells.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
194	Leyte	Tacloban	Daguitan River	U	For use as sand blast	2.50	130433	June 11, 1919	Andesite, some feldspar, and quartz.
195	Do	do	Kilometer 4	U	Tacloban wharf	0.75	146284B	Mar. 27, 1923	Quartz, corals, and shells.
196	Do	do	Sabang beach	U	do	0.75	146284C	do	Do.
197	Do	do	do	U	do	2.00	150161B	Feb. 12, 1924	Fine andesite and quartz.
198	Do	do	Tigbao River		Tacloban port works	0.80	121583	Dec. 15, 1915	Quartz, sandstone, and andesite.
199	Do	Tanauan	Malaguicay River		Provincial public works		147651I	July 11, 1923	Basalt and magnetite.
200	Marinduque	Boac	Boac seashore	U	Boac pier construction	1.20	155971	Mar. 17, 1925	Andesite, basalt, and quartz.
201	Do	Gasan	Gasan beach		Gasan-Buenavista road		119706	Jan. 25, 1915	
202	Do	do	Matandang Asan River.	U	Matandang Asan Bridge.	0.50	151128A	Apr. 11, 1924	Weathered basalt.
203	Do	do	Gasan beach	U	do	0.50	151128B	do	Andesite and quartz.
204	Do	do	Tiguian River		Gasan-Buenavista road		119706	Jan. 25, 1915	
205	Masbate	Masbate	Baleno seashore	A	Masbate market	5.00	153778	Oct. 23, 1924	Andesite and diorite.
206	Do	do	Togbo River	A	do	5.00	152783	Aug. 7, 1924	Andesite and basalt.
207	Do	Milagros	Asid River	U	Milagros School	5.00	149618	Dec. 26, 1923	Andesite and basalt (weathered).
208	Do	do	Lumbang River	U	do	7.00	149505	Dec. 22, 1923	Do.
209	Mindanao [b]	Cagayan (Misamis).	Cagayan River		Cagayan wharf		122045A	Mar. 10, 1916	Basalt and quartz.

210	Do	do	Cagayan beach		do		122045B	do	Basalt, quartz, and shells.
211	Do	do	Cagayan River		Cagayan Central School.	2.00	123101	Aug. 24, 1916	Do.
212	Do	do	Iponan River		Iponan and Molugan School.		141781	Feb. 20, 1922	Weathered andesite, quartz and feldspar.
213	Do	do	Mouth of Cugman River.		Macabalan wharf		122187	Apr. 10, 1916	Magnetite, olivine, and quartz.
214	Do	Cotabato (Cotabato).	Cotabato River	U	Cotabato Hospital tank	1.50	148647	Oct. 9, 1923	Tuff, pumice, and cinders.
215	Do	do	Rio Grande	U	do	1.50	147911	Aug. 2, 1923	Limestone-rock screenings.
216	Do	do	Linuac beach		do		121499	Nov. 30, 1915	Quartz and shells.
217	Do	do	do		do		124391	Apr. 17, 1917	Corals, shells, and quartz.
218	Do	Davao (Davao)	Davao River, 2.5 kilometers distant.	U	Davao wharf	2.75	157985	July 16, 1925	Basalt and andesite.
219	Do	do	Davao River, 3.5 kilometers distant.	U	do	2.75	157986	do	Do.
220	Do	Jolo (Sulu)			Miscellaneous works		118287	Feb. 21, 1914	Corals and shells.
221	Do	do	Baliwasan beach (Zamboanga).	U	Jolo wharf	8.00	148237A	Sept. 3, 1923	Basalt and coralline.
222	Do	do	do	U	do	8.00	148237B	do	Do.
223	Do	do	Caldera Bay	U	do	5.00	148237C	do	Basalt and quartz.
224	Do	do	Tumaga River (Zamboanga).	U	do	10.00	148237D	do	Do.
225	Do	do	Maimbung River		Culverts	4.50	125574	Nov. 1, 1917	Volcanic sand and quartz.
226	Do	Surigao (Surigao).	Surigao beach		High School building		152656	July 29, 1924	Basalt and andesite.
227	Do	Zamboanga (Zamboanga).	Baliwasan beach	U	Zamboanga wharf extension.	1.50	156546A	Apr. 16, 1925	Basalt, andesite, and corals.
228	Do	do	do	U	do	1.50	156546B	do	Do.

[b] Tested at the age of 18 days and 30 days, respectively.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
229	Mindanao	Zamboanga (Zamboanga).	Tumaga River (Zamboanga).		Zamboanga waterworks.		122303A	Apr. 26, 1916	Basalt, andesite, and quartz.
230	Do.	do.	do.		do.		122303B	do.	Do.
231	Do.	do.	Zamboanga beach	U	Jolo wharf	1.50	147515	July 2, 1923	Basaltic.
232	Do.	do.	do.	U	do.	2.00	154786	Jan. 6, 1925	Basalt and corals.
233	Do.	do.			Zamboanga Normal	2.00	127040	Feb. 6, 1918	Decayed metaphormic.
234	Do.	do.			do.	0.90	127041	do.	Hard basalt and corals.
235	Nueva Ecija	Caranglan	Caranglan River	U	Kabolinawan Bridge	1.50	147350	June 19, 1923	
236	Do.	Cabanatuan	Rio Grande	U	Provincial Hospital	2.00	150669	Mar. 15, 1924	Basalt and andesite.
237	Occidental Negros.	Bacolod	Lupit River	U	Bacolod Provincial Hospital.	3.00	149510	Dec. 22, 1923	Basalt and feldspar.
238	Do.	do.	do.	U	do.	2.50	156703	Apr. 27, 1925	Andesite and feldspar.
239	Do.	Bago	Bago River	U	Bago School extension.	2.00	151982	June 10, 1924	Basalt, andesite, and quartz.
240	Do.	Binalbagan	Binalbagan River	U	Binalbagan School	2.00	149507	Dec. 22, 1923	Basalt.
241	Do.	Cadiz	Talabaan River		Cadiz municipal market	5.00	158885	Sept. 10, 1925	Weathered argillaceous.
242	Do.	Himamaylan	Talabaan-Diot River.	U	Himamaylan School	4.00	150855	Mar. 25, 1924	Andesite and basalt weathered.
243	Do.	Isabela	Binalbagan River	U	Isabela School	3.50	153663	Oct. 16, 1924	Do.
244	Do.	do.	Guintubhan River	U	do.	3.50	154169	Dec. 21, 1924	Andesitic porphyry.
245	Do.	La Carlota	Alejandria River	U	La Carlota School	2.00	148964	Nov. 3, 1923	Basalt.

246	Do.	La Castellana	Bungahin River		La Castellana municipal building.	2.50	158983	Sept. 17, 1925	Basalt and hornblende.
247	Do.	do.	do.	U	do.	2.00	159768	Nov. 3, 1925	Basic igneous.
248	Do.	Maao	Maragandang River	U	Maao School	3.00	150748	Mar. 19, 1924	Andesite and quartz.
249	Do.	Pulupandan	Bago River	U	Pulupandan wharf		158271	July 31, 1925	Andesite and basalt, weathered.
250	Do.	Talisay	Matabang River	U	Talisay School	2.00	151004	Apr. 3, 1924	Andesite and quartz.
251	Oriental Negros.	Bais	Bais River		Bais River Bridge		122046	Mar. 10, 1916	Coralline and quartz.
252	Do.	Dumaguete	Banica River	U	Storage tank	2.40	145642A	Feb. 5, 1923	Granitic sand and quartz.
253	Do.	do.	Ocoy River	U	do.	6.00	145642B	do.	Do.
254	Palawan	Coron	Banga River	U	Coron wharf	4.00	155109	Jan. 23, 1925	Feldspar, very much weathered.
255	Do.	do.	Beach near wharf	U	do.		157987	July 16, 1925	Feldspar.
256	Do.	do.	Coron beach		do.		124014	Feb. 6, 1917	Iron-stained quartz.
257	Pampanga	Angeles	Abacan River	A	Angeles Bridge No. 89	3.00	146673	Apr. 25, 1923	Angular glassy feldspar.
258	Do.	do.	do.	A	do.		147419	June 22, 1923	Andesite.
259	Do.	Floridablanca	Valdez River	A	Floridablanca market		159229	Oct. 2, 1925	Limestone and quartz.
260	Do.	do.	do.	A	do.		159887	Nov. 11, 1925	Feldspar and quartz.
261	Do.	Magalang	Quintangil River	A	Magalang municipal building	2.50	146671	Apr. 25, 1923	Basalt and quartz.
262	Do.	Mexico	Barrio San Agustin	A	Santa Ana School		149486A	Dec. 20, 1923	Andesite and quartz.
263	Do.	do.	Barrio Santo Rosario	A	do.		149486B	do.	Do.
264	Pangasinan	Aguilar	Aguilar River	U	Aguilar School	1.75	146985	May 22, 1923	Diorite.
265	Do.	Alcala	Barrio San Juan	U	Alcala School	3.50	144572	Nov. 14, 1922	Basalt and feldspar.
266	Do.	Anda	Balincanguin River	U	Anda School	5.00	146986	May 22, 1923	Ferromagnesian and feldspar.
267	Do.	Balungao	Villasis River	U	Balungao School	4.00	146157	Mar. 17, 1923	Basic volcanic and feldspar.
268	Do.	Bautista	Agno River	U	Bayambang School	3.70	147818	July 25, 1923	Basalt, andesite, and feldspar.
269	Do.	Bani	Agno River at Labrador.	U	Bani School	5.00	145627	Feb. 3, 1923	Angular feldspar.

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						Pesos.			
270	Pangasinan	Bolinao	Piluluban River	U	Bolinao School	5.00	152865	Aug. 14, 1924	Coralline limestone.
271	Do	Burgos	Tambacan	U	Burgos Central School	4.00	145188	Dec. 27, 1922	Volcanic rock.
272	Do	Calasiao	Abeloleng River at San Jacinto.	U	Calasiao Central School	4.00	144639	Nov. 17, 1922	Basalt and feldspar.
273	Do	do	Calasiao-Malabago River.	U	Provincial Hospital	3.50	153589	Oct. 11, 1924	Do.
274	Do	do	Malabago River	U	Calasiao School	2.60	144200	Oct. 18, 1922	Feldspar.
275	Do	do	Mariquita River	U	do	4.00	145277	Jan. 4, 1923	Do.
276	Do	do	Santa Barbara River	U	do	3.00	145189	Dec. 27, 1922	Feldspar and quartz.
277	Do	do	Tarlac River	U	do	2.00	145099	Dec. 19, 1922	Glassy feldspar.
278	Do	Dagupan	San Jacinto-Canoleng River.	U	Provincial Hospital	4.00	152549	July 22, 1924	Basalt and andesite.
279	Do	Lingayen	Labrador River	U	Lingayen High School	3.50	149973	Jan. 31, 1924	Do.
280	Do	Malasiqui	Malasiqui River	U	Malasiqui School	2.00	146044	Mar. 10, 1923	Ferromagnesian and quartz.
281	Do	do	do	U	do	2.40	146427	Apr. 10, 1923	Andesitic.
[illegible]	Do	Manaog	Asingan River	U	Manaog School building.	2.20	152247	June 30, 1924	Weathered grains, basalt, and andesite.
283	Do	Santa Barbara	Santa Barbara River.	U	Provincial Hospital	4.50	153605	Oct. 13, 1924	Andesite and feldspar.
284	Do	San Carlos	Ano Nilintap (Malasiqui).	U	San Juan Bridge	2.80	149821	Jan. 21, 1924	Basalt, feldspar, and shells.
285	Do	do	Abeloleng River	U	San Carlos School		144407	Nov. 3, 1922	Basalt and quartz.
286	Do	do	Bogtung River	U	San Juan Bridge	2.30	150493	Mar. 5, 1924	Basalt, andesite, and shells.

287	Do.	do.	Malabago River	U	San Carlos School building.	2.50	143742	July 7, 1922	Feldspar and andesite.
288	Do.	do.	River bank at San Fabian.	A	do.	4.20	143265	July 19, 1922	Volcanic and feldspar.
289	Do.	San Jacinto	Mapandan River	A	San Jacinto School building.	3.00	145345	Jan. 9, 1923	Do.
290	Do.	do.	San Jacinto River	A	do.	2.00	145666	Feb. 7, 1923	Andesite angular.
291	Do.	Tayug	Agno River	A	Tayug School	1.50	144072	Oct. 6, 1922	Andesite and feldspar.
292	Rizal	Las Piñas	Las Piñas River		Las Piñas Bridge		80997	Aug. 16, 1910	Vesicular lava.
293	Do.	Mariquina	Mariquina River	A	Angona Bridge		121816	Jan. 27, 1916	Basalt, magnetite, and quartz.
294	Do.	do.	do.	U	Zamboanga waterworks.		122021	Mar. 7, 1916	Andesite, basalt, and quartz.
295	Do.	do.	do.	U	Pier No. 7, Manila		158001	July 17, 1925	Andesite and basalt.
296	Do.	do.	do.	U	do.		158318A	Aug. 4, 1925	Do.
297	Do.	do.	do.	U	do.		158318B	do.	Do.
298	Do.	McKinley	Pasig River	U	Legislative Building, Manila.	2.00	151600A	May 14, 1924	Do.
299	Do.	do.	do.	U	do.	2.00	151600B	do.	Do.
300	Do.	do.	do.	U	Jones Bridge subway		151984	June 10, 1924	Do.
301	Do.	do.	do.	U	Legislative Building, Manila.	2.50	152145	June 20, 1924	Do.
302	Do.	Novaliches	Novaliches River		Novaliches Bridge		65401	Feb. 24, 1909	
303	Do.	Pasig River	Pasig River	A	Fort McKinley		94269	Nov. 17, 1911	Basalt and shells.
304	Do.	do.	do.	U	Legislative Building, Manila.	2.00	130366	May 26, 1919	Basalt and andesite.
305	Do.	do.	do.	U	San Luis municipal building, Batangas.	3.00	146939	May 19, 1923	Andesite, diorite, and quartz.
306	Do.	do.	do.	U	Indang waterworks, Cavite.	4.50	147303	June 16, 1923	Basalt.
307	Do.	do.	do.	U	University of the Philippines chemical laboratory.	3.00	149466	Dec. 18, 1923	Basalt and andesite.
308	Do.	do.	do.	U	Legislative Building, Manila.	2.40	145643A	Feb. 5, 1923	Andesite.

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						Pesos.			
309	Rizal	Pasig	Pasig River	U	Legislative Building, Manila.	2.40	145643B	Feb. 5, 1923	Andesite.
310	Do.	do.	do.	U	do.	2.40	145643C	do.	Do.
311	Do.	do.	do.	U	do.	2.40	145643D	do.	Do.
312	Do.	do.	do.	U	Pasay concrete road	3.50	149666	Jan. 8, 1924	Basalt and andesite.
313	Do.	do.	do.	U	do.	4.00	149777	Jan. 17, 1924	Basalt and diorite.
314	Do.	do.	Pasig River (Bambang).	U	Jones Bridge, Manila	2.40	152173	June 23, 1924	Basalt and andesite.
315	Do.	do.	Pasig River	U	Legislative Building, Manila.	2.50	154012	Nov. 11, 1924	Do.
316	Do.	do.	do.	U	Philippine General Hospital.	3.20	153845	Oct. 29, 1923	Basalt and andesite.
317	Romblon	Romblon	Seashore	U	Romblon concrete pier	3.00	144383	Nov. 1, 1922	Coralline.
318	Do.	do.	do.	U	do.	3.00	144776	Nov. 25, 1922	Corals and shells.
319	Do.	do.	do.	U	do.	3.00	144777	do.	Coralline.
320	Do.	do.	Beach at Sitio Bantayan.	U	Romblon radio tower		138831	June 11, 1921	Do.
321	Samar	Borongan	Bato River at Canabong.		Borongan Bridge		151148A	Apr. 12, 1924	Andesite and basalt.
322	Do.	do.	Borongan River at Sulop.		do.		151148B	do.	Weathered andesite and basalt.
323	Do.	do.	Canabon beach		do.		151148C	do.	Andesite and basalt.
324	Do.	do.	Mayhaligue River	U	do.		150108A	Feb. 8, 1924	Very much weathered basalt.

325	Do	do	Sabang River	U	do		150108B	do	Slightly weathered basalt.
326	Do	do	Soribas beach		do		151148D	Apr. 12, 1924	Andesite and basalt.
327	Do	do	Sunco beach near Sabang.		do		151148E	do	Do.
328	Do	Calbayog	Calbayog beach		Calbayog north and south bridges.		118232A	Feb. 12, 1924	Andesite.
329	Do	do	do		do		119453	Nov. 16, 1924	Do.
330	Do	do	Calbayog beach (pit).		do		118232B	Feb. 12, 1924	Sandstone, shale, and quartz.
331	Do	do	Malopalo Tinambacan.		Calbayog municipal building.	3.00	154091	Nov. 14, 1924	Andesite and feldspar.
332	Do	do	Tagdaranao beach	U	do	5.00	154357	Dec. 4, 1924	Andesite.
333	Do	Catarman	Seashore	U	Catarman market		151088	Apr. 9, 1924	Quartz.
334	Do	Catbalogan	Near water reservoir.	U	Catbalogan waterworks		145565	Jan. 27, 1923	Volcanic and quartz.
335	Do	Llorente	River at Sinacan		Llorente School building.	2.00	152714	Aug. 2, 1924	Andesite and basalt.
336	Do	do	Llorente beach		do	0.80	152715	do	Do.
337	Do	do	Llorente River at Lubuagan.		do	2.00	152730	do	Do.
338	Sorsogon	Bulan	San Ramon River	U	Bulan market		160425	Dec. 23, 1925	Basalt and andesite.
339	Do	Castilla	Yawa River (Daraga)	U	Kinadkad Bridge		159122	Sept. 25, 1925	Volcanic.
340	Do	do	do	U	do		159767	Nov. 3, 1925	Do.
341	Do	Donsol	Donsol River	U	Donsol market	4.00	147547	July 5, 1923	Basalt.
342	Do	Gubat	Ariman River	U	Sagurong Bridge	3.00	150908	Mar. 28, 1924	Weathered andesite and quartz.
343	Do	do	Sagurong River	U	do	2.50	150246	Feb. 16, 1924	Weathered basalt.
344	Do	Juban	Juban River	U	Juban School	1.50	150556	Mar. 28, 1924	Weathered andesite.
345	Do	do	Talinga River	U	do	2.00	151089	Apr. 9, 1924	Andesite and quartz.
346	Do	Sorsogon	Lantic River		Sorsogon waterworks	1.60	154358	Dec. 4, 1924	Andesite and weathered diorite.
347	Do	do	Sorsogon	A	do	1.80	153779	Oct. 23, 1924	Volcanic.
348	Do	do	do	A	Provincial Hospital		160254	Dec. 10, 1925	Diorite, angular.
349	Surigao	Bilangbilang	Surigao River	A	Bilangbilang wharf		121256	Oct. 25, 1915	Limestone and quartz.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; L, limited; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter delivered at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
350	Surigao	Bilangbilang	Surigao River at wharf.	A	Bilangbilang wharf		121257	Oct. 25, 1915	Quartz, basalt, and andesite.
351	Tarlac	Camiling	Camiling River		Camiling market		117776	Oct. 30, 1913	Feldspar, ferromagnesian.
352	Do	Capaz	Santiago River		Capaz-Concepcion road		123447	Nov. 1, 1916	Feldspar.
353	Do	O'Donnell	O'Donnell River		O'Donnell irrigation works.		84560A	Nov. 22, 1910	Feldspar, pumice, and quartz.
354	Do	do	do		do		84560B	do	Do.
355	Do	Paniqui	Tarlac River		Paniqui School building.		157694	June 27, 1925	Feldspar and quartz.
356	Do	San Miguel	Cutcut River		O'Donnell irrigation works.		158312	Aug. 4, 1925	Granitic and quartz.
357	Do	do	O'Donnell River	U	do		160177	Dec. 3, 1925	Quartz and feldspar.
358	Do	Tarlac	Tarlac River	U	do		75663	Jan. 6, 1910	Andesite, feldspar, and hornblende.
359	Do	do	Tarlac	U	do		75663	do	Do.
360	Tayabas	Candelaria	Candelaria-Tiaong, 18.2 kilometers.		Lucena-Tiaong road		125876	Dec. 8, 1917	Angular volcanic.
361	Do	do	Cuyapo River	A	Candelaria waterworks.	2.50	156807	May 4, 1925	Andesite and diorite.
362	Do	Infanta	Agos River	A	Infanta municipal building.	2.50	158970	Sept. 16, 1925	Diorite.
363	Do	do	Lamigan River	A	do	3.50	158375	Aug. 7, 1925	Weathered andesite.

364	Do.	Lopez	Siain beach	A	Lopez municipal building.		160352	Dec. 18, 1925	Andesite, limestone, and quartz.
[illegible]	Do.	Lucena	Dumacaa River	A	Hospital building	2.10	149688	Jan. 10, 1924	Andesite.
[illegible]	Do.	Sariaya	Munting River, Pit No. 1.		Lucena-Tiaong road	0.75	125700	Nov. 22, 1917	Basalt.
367	Do.	Siain	Siain beach	A			159068	Sept. 22, 1925	Quartz, limestone, and shells.
368	Do.	Tayabas	Alitao River	A	Tayabas market	6.50	152450	July 12, 1924	Weathered basalt and andesite.
369	Do.	Tiaong	300 meters from bridge.		Lagnas River Bridge		142927	June 16, 1922	Scoriaceous basalt and quartz.
370	Do.	do.	Just below bridge	U	do.	2.50	143315	July 24, 1922	Weathered basalt.
371	Do.	do.	Mainit River	U	Tiaong waterworks	2.50	156808	May 4, 1925	Weathered andesite.
372	Do.	Unisan	Banks of Kalylayan River.	U	Kalylayan Bridge	4.00	154615	Dec. 20, 1924	Quartz and diorite.
373	Zambales	Alhambra	Mouth of Lucapon River.	U	Lucapon Bridge	0.50	123119	Aug. 28, 1916	Volcanic quartz and shells.
374	Do.	Cabangan	Anunang River	U	Anunang Bridge	1.00	121917	Feb. 16, 1925	Weathered andesite and quartz.
375	Do.	do.	Mouth of Cauayan River.	U	Iba-Subic Road Bridge	2.00	121641	Dec. 23, 1925	Feldspar.
376	Do.	do.	Kauayan-Kiling River.	U	do.	1.00	121640	do.	Andesite, basalt, and feldspar.
377	Do.	do.	Lauis River	U	Yamot River Bridge	1.50	122530	June 5, 1916	Andesite and feldspar.
378	Do.	do.	Yamot River	U	do.	2.00	122531	do.	Feldspar, some olivine, and pyroxene.
379	Do.	Candelaria	Sitio Galagala	U	Candelaria School building.	2.45	123118	Aug. 28, 1916	Volcanic and feldspar.
380	Do.	Santa Cruz	Bayto River	U	Santa Cruz School	3.00	146669	Apr. 25, 1923	Basalt.
381	Do.	do.	Perpetuo River	U	do.	1.75	145824	Feb. 21, 1923	Ferromagnesian.
382	Do.	San Marcelino	Santo Tomas River at Santa Fé.	U	Santo Tomas irrigation works.		153274	Sept. 15, 1924	Feldspar and quartz.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screens.									Three-screen analysis. Per cent particles.			Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar).				Compressive strength in pounds per square inch (1:3 mortar).				Strength at the age of 28 days. $\frac{\text{Specimen}}{\text{standard}} \times 100$.	
																Sand specimens.		Standard sand.		Sand specimens.		Standard sand.			
	10	20	30	40	50	60	80	100	200	Coarse.	Medium.	Fine.				7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	Tensile.	Compressive.
1	88	66	41	27	19	13	6	4	----	23	58	19	2.72	40.1	3.1	217	246	267	324	1460	2010	1864	2610	76.1	77.1
2	93	66	38	22	13	7	4	3	1	20	67	13	2.75	37.1	3.2	250	304	227	347	1930	3410	1910	3380	87.6	100.9
3	85	55	27	17	10	3	1	0.7	----	33	57	10	2.69	42.1	2.8	246	352	354	402	1375	2600	1611	2472	87.3	105.2
4	85	52	26	12	7	4	3	2	1	34	59	7	2.72	41.2	2.4	206	317	284	403	1877	3283	2119	2780	104.5	118.2
5	71	48	29	17	12	7	3	2	1	40	48	12	2.85	41.5	3.5	211	328	284	403	1533	2890	2119	2780	81.4	104.2
6	87	62	38	21	12	6	3	2	1	26	62	12	2.61	40.9	2.6	165	233	243	361	1361	2116	1878	2468	64.5	85.6
7	91	41	25	16	9	7	4	3	2	40	51	9	2.58	34.3	3.3	196	234	255	365	1659	2593	1923	2777	63.9	93.5
8	79	53	35	22	16	10	5	2	----	38	46	16	2.80	37.1	4.2	250	380	270	362	1550	2537	1925	2787	105.0	93.1
9	96	68	34	25	19	14	10	5	----	21	60	19	2.73	33.1	3.6	275	280	316	390	2415	2955	2550	2906	71.8	101.5
10	82	53	40	34	27	23	12	9	----	38	35	27	2.66	27.1	6.1	291	348	317	333	2528	3500	2182	3182	104.1	110.1
11	98	25	3	----	----	----	----	----	----	52	48	0	2.70	36.1	2.1	258	380	236	349	1470	2920	1330	2994	109.1	97.6
12	86	10	2	----	----	----	----	----	----	72	28	0	2.70	35.1	1.8	271	409	236	349	1540	2994	1330	2994	117.1	100
13	94	57	33	16	9	4	2	1	----	30	61	9	2.61	33.2	2.5	163	327	241	339	904	2197	1704	2328	96.5	94.4
14	94	44	15	5	3	2	----	----	----	36	61	3	2.62	35.1	2.1	210	322	241	339	1330	2884	1704	2328	95.1	124.1
15	100	97	93	77	54	28	14	8	2	2	44	54	2.97	39.7	1.6	145	229	241	346	998	1179	2148	3108	66.2	37.9
16	92	74	52	33	17	9	4	3	2	16	67	17	2.62	36.7	2.3	119	235	222	340	799	1525	2100	3230	69.1	47.3
17	82	48	24	12	7	4	3	2	----	37	56	7	2.65	36.1	2.7	206	310	220	313	1410	2695	1575	2618	99.1	103.1
18	88	62	42	27	12	7	2	1	----	26	62	12	2.62	44.1	2.6	175	303	220	313	1048	2039	1424	2994	97.1	68.1
19	74	32	22	5	3	2	----	----	----	46	51	3	2.80	36.2	2.3	290	356	241	339	1476	2921	1704	2328	105.1	125.8
20	96	76	37	16	9	3	2	----	----	16	75	9	2.65	35.9	1.9	157	260	241	339	935	1843	1704	2328	76.7	79.1
21	88	63	43	32	25	16	8	5	----	27	48	25	2.73	33.1	3.7	269	307	315	402	2440	3473	2175	3203	76.4	77.1
22	92	53	17	4	3	2	2	2	1	22	75	3	2.70	42.1	2.1	286	395	286	403	1560	2720	2100	2722	98.1	99.8
23	100	98	88	78	56	38	18	9	----	1	43	56	2.75	50.1	1.9	141	249	277	366	673	948	----	----	68.1	----

24	95	74	36	21	8	3	2	1	----	29	63	8	2.55	------	2.1	-----	[a] 312	-----	[a] 340	------	[a] 4587	----	[a] 4288	91.8	107.1
25	98	80	40	21	9	7	5	3	2	11	80	9	2.67	38.1	2.1	180	262	251	370	1065	1863	1608	2612	70.8	71.2
26	89	57	33	18	9	7	5	3	2	32	59	9	2.68	38.6	2.5	202	261	280	371	1172	2749	1737	2477	70.5	111.1
27	92	74	52	37	23	13	7	4	2	19	38	23	2.93	37.2	3.1	262	284	281	352	1763	3219	1897	2595	80.7	124.1
28	84	60	37	27	20	12	8	7	5	27	53	20	2.82	29.3	4.1	241	246	281	352	1672	2571	1897	2595	70.0	99.1
29	94	48	17	9	7	4	3	2	1	31	62	7	2.67	38.5	2.4	219	344	281	352	1422	2371	1897	2595	97.9	91.5
30	98	92	73	51	30	20	12	7	3	4	66	30	2.75	40.1	2.3	107	220	282	333	889	1737	1714	2318	66.1	75.1
31	83	48	23	9	5	3	2	1	----	33	62	5	2.66	35.5	2.3	213	331	282	333	1678	2903	1714	2318	99.5	125.6
32	78	44	21	12	8	4	3	2	1	40	52	8	2.61	34.2	3.1	209	328	282	333	1698	2283	1714	2318	98.5	98.5
33	74	33	14	8	4	3	2	1	----	46	50	4	2.26	41.6	2.7	210	300	304	410	1510	2342	1950	2830	73.2	82.9
34	88	57	28	12	6	3	2	2	1	28	66	6	2.31	41.1	2.3	160	239	290	403	1111	1376	2130	2722	59.3	50.5
35	97	67	25	8	4	2	1	----	----	14	82	4	2.30	39.1	2.1	128	220	244	350	653	1337	1803	2397	62.8	55.8
36	98	74	53	32	17	7	3	2	----	16	67	17	2.52	42.1	3.1	164	242	304	410	995	1845	1950	2830	59.1	65.2
37	57	26	12	6	4	3	2	1	----	62	34	4	2.24	37.1	3.2	208	284	268	387	1194	2059	1596	2279	73.3	90.4
38	93	77	54	37	26	14	8	6	2	14	60	26	2.55	39.8	3.1	206	305	246	335	1340	2236	2102	2712	91.1	82.5
39	61	28	15	8	5	3	2	1	----	60	35	5	2.32	46.4	3.1	173	265	269	394	906	1693	1668	2708	67.3	62.5
40	99	76	43	24	16	9	6	4	2	8	76	16	2.66	51.1	2.7	152	214	251	370	773	1583	1811	2762	57.8	57.2
41	100	96	87	75	56	30	15	8	2	4	40	56	2.75	44.2	2.1	137	207	252	361	943	1709	1913	3045	57.4	56.1
42	94	50	26	17	11	8	5	4	2	28	61	11	2.43	41.1	2.9	169	257	276	341	1118	2309	1948	2609	75.3	88.5
43	97	72	37	27	7	3	2	1	----	11	82	7	2.81	41.1	2.1	198	306	255	390	1235	2330	1756	2688	78.5	86.9
44	48	23	13	8	6	4	3	3	3	14	80	6	2.55	38.4	4.6	331	456	240	326	1990	3500	1732	2121	140.1	164.6
45	91	83	77	74	70	66	63	58	30	15	15	70	2.66	49.6	4.1	131	189	240	326	611	1110	1732	2121	58.1	52.2
46	74	43	24	17	12	8	6	4	2	45	43	12	2.60	39.6	4.5	460	452	259	336	1209	2783	1027	1576	134.6	108.1
47	99	94	79	69	42	25	14	6	----	4	54	42	2.85	44.5	2.1	148	220	266	343	-----	------	------	-----	64.1	-------
48	70	44	33	23	20	17	15	12	---	47	33	20	2.54	44.8	8.4	395	504	266	343	-----	------	-----	-----	147.0	-------
49	----	----	97	86	79	60	32	17	1	-------	21	79	2.67	39.8	2.4	132	168	276	332	1672	2078	2145	3499	50.6	59.4
50	70	35	17	9	7	4	3	2	----	49	44	7	2.29	45.8	3.1	164	220	310	432	657	996	2631	3428	50.8	29.6
51	97	77	59	47	38	26	17	12	3	16	46	38	2.69	39.4	3.2	235	270	319	371	1722	2393	2394	3394	72.8	70.5
52	97	81	53	32	20	12	7	3	2	8	72	20	2.56	43.4	2.1	153	239	273	388	1350	2093	2559	2969	61.6	70.7
53	98	88	65	43	28	16	10	7	3	6	66	28	2.65	31.1	2.7	186	255	254	319	821	1413	1810	2155	80.1	65.6
54	98	95	86	71	46	14	4	2	----	4	50	46	2.77	46.1	1.5	123	225	285	373	660	864	1881	2310	82.3	37.4
55	47	8	3	--	----	--	---	----	----	53	47	------	2.67	48.9	2.5	253	353	289	392	1805	2648	1886	2730	90.1	96.8
56	97	83	47	13	7	3	2	2	2	10	83	7	2.62	37.8	1.5	256	322	273	388	1794	3088	2559	2969	83.1	104.1

[a] Proportion of mortar mixture by weight 1 : 2.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screen. 10	20	30	40	50	60	80	100	200	Three-screen analysis. Per cent particles. Coarse.	Medium.	Fine.	Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar). Sand specimens. 7 days.	Sand specimens. 28 days.	Standard sand. 7 days.	Standard sand. 28 days.	Compressive strength in pounds per square inch (1:3 mortar). Sand specimens. 7 days.	Sand specimens. 28 days.	Standard sand. 7 days.	Standard sand. 28 days.	Strength at the age of 28 days. Specimen/standard × 100. Tensile.	Compressive.
57	----	82	38	15	6	3	2	2	1	7	87	6	2.68	32.3	1.7	214	301	240	299	1148	1919	2012	3045	100.8	63.1
58	100	96	61	35	17	10	7	4	2	2	81	17	2.75	37.4	2.1	228	279	273	388	2238	3466	2559	2969	72.1	117.1
59	100	98	94	67	36	6	3	2	1	1	63	36	2.81	40.4	1.7	190	252	247	309	1385	2132	2127	3379	81.5	63.1
60	97	87	56	25	10	4	3	2	----	8	82	10	2.65	40.1	1.7	149	242	273	340	1585	2159	2559	3189	71.1	67.7
61	99	98	95	73	60	20	6	3	2	-------	40	60	2.66	40.3	1.2	151	216	279	367	734	1534	1784	3020	58.8	50.9
62	98	48	13	7	5	4	3	2	1	20	75	5	2.68	39.1	1.8	185	293	279	367	1624	2390	1784	3020	80.1	79.2
63	----	---	100	93	84	57	38	22	2	0	16	84	2.73	42.6	2.3	151	192	257	319	408	580	1092	2109	60.3	20.6
64	98	96	80	42	18	8	2	1	0.5	3	79	18	2.67	39.3	1.7	183	259	257	319	651	1204	1092	2109	81.2	57.1
65	93	75	45	13	4	2	2	----	----	14	82	4	2.59	38.5	1.7	187	232	300	342	895	1450	1516	2002	67.8	72.5
66	28	4	2	1	----	----	----	----	----	88	12	0	2.63	37.2	2.7	313	392	240	369	2042	2780	1916	3245	106.2	85.5
67	85	60	16	4	2	1	----	----	----	28	70	2	2.69	41.3	1.7	264	369	240	369	2139	2450	1916	3245	100.0	75.5
68	24	4	2	----	----	----	----	----	----	90	10	0	2.53	43.3	2.6	234	314	247	353	1198	2297	1330	2363	89.1	96.8
69	100	97	92	86	53	15	7	4	1	3	44	58	2.67	41.4	2.1	113	182	223	332	811	1704	1758	2969	55.1	57.4
70	98	93	75	35	14	7	4	3	0	4	82	14	2.81	53.6	1.6	154	202	276	332	1164	1371	2145	3499	69.8	39.2
71	----	98	94	87	65	22	16	12	6	1	34	65	2.78	46.4	1.5	172	218	276	332	1165	1576	2145	3499	65.7	39.4
72	82	60	32	16	5	7	3	2	0	30	65	5	2.79	46.8	2.1	162	257	276	332	1188	1349	2145	3499	77.4	38.4
73	97	88	77	58	39	16	12	6	2	6	55	39	2.83	47.6	2.1	167	270	276	332	1236	1834	2145	3499	81.3	52.5
74	98	92	76	68	39	16	8	6	1	6	55	39	2.72	46.1	1.8	220	306	301	408	1913	2531	2986	3788	75.1	66.8
75	68	39	21	11	6	4	2	1	----	48	46	6	2.62	41.8	3.4	275	371	285	373	1843	2359	1886	2310	99.5	101.8
76	98	58	25	12	7	3	2	1	----	19	74	7	2.58	37.1	2.2	203	258	241	331	1012	1626	1590	2564	78.1	63.2
77	27	4	1	----	----	----	----	----	----	88	12	------	2.55	36.1	2.6	296	388	241	331	2020	2689	1590	2564	117.1	104.8
78	98	93	72	48	10	8	3	2	----	4	86	10	2.65	30.1	1.8	177	237	281	388	1240	1980	2230	3730	70.1	51.7
79	93	58	27	15	10	7	6	5	3	26	64	10	2.74	28.1	2.4	334	398	251	330	2551	4706	1940	2705	121.1	174.1

80	92	71	34	----	17	----	----	----	----	20	68	17	2.69	41.8	3.4	170	----	248	----	[a] 1775	----	----	----	----	----
81	49	14	8	5	3	2	1	0.5	----	73	24	3	2.67	34.8	3.6	----	----	----	----	----	2469	----	----	----	----
82	92	67	80	13	7	4	3	2	----	18	75	7	2.62	35.1	2.1	193	307	221	337	1620	2420	1800	2720	91.1	89.1
83	87	67	43	27	17	10	6	4	1	24	59	17	2.72	39.6	3.1	217	----	234	----	1403	----	1532	----	----	----
84	67	52	27	17	10	5	4	2	2	47	43	10	2.71	34.2	4.2	223	387	261	414	1885	3336	1875	3429	93.5	97.4
85	84	64	39	25	16	8	6	4	2	26	58	16	2.69	38.2	2.7	216	350	261	414	1617	3324	1875	3429	84.6	97.1
86	94	90	80	61	28	14	8	6	3	7	65	28	2.62	40.7	1.8	110	191	261	414	712	1309	1875	3429	46.2	38.2
87	72	41	21	13	10	6	4	1	----	48	42	10	2.63	21.8	3.8	307	518	264	353	2485	4336	2133	2820	146.1	153.5
88	97	68	40	22	11	7	4	3	2	18	71	11	2.80	30.7	2.2	254	356	258	352	1428	2626	1711	2622	101.1	100.1
89	94	55	27	13	5	3	2	1	1	27	68	5	2.73	30.5	2.3	203	272	272	349	1935	2138	1900	2624	78.1	81.2
90	95	75	43	18	13	5	3	2	1	13	74	13	2.73	28.4	2.7	207	306	258	352	1273	2113	1711	2622	87.1	80.6
91	97	55	27	17	11	7	4	3	2	23	66	11	2.72	26.9	2.7	209	311	258	352	1392	3200	1711	2622	88.5	121.8
92	94	71	32	15	7	4	2	1	----	18	75	7	2.67	41.5	1.9	223	334	266	343	----	----	----	----	97.5	----
93	98	89	68	46	15	8	5	4	----	7	78	15	2.70	36.8	1.7	----	----	----	----	----	1507	----	----	----	----
94	87	78	65	13	2	----	----	2	----	18	80	2	2.69	40.4	1.3	[b] 264	[b] 271	[c] 228	[c] 270	----	----	----	----	----	----
95	94	80	46	18	6	3	2	1	1	12	82	6	2.66	31.8	1.9	260	360	272	349	1682	2281	1900	2624	103.1	87.1
96	60	32	21	17	9	4	2	1	----	58	33	9	2.72	28.2	4.7	----	----	----	----	----	2460	----	----	----	----
97	97	87	67	43	24	7	6	4	2	7	69	24	2.69	32.4	2.1	156	213	251	370	1078	1817	1608	2612	57.7	69.6
98	97	85	55	43	25	12	6	3	----	10	65	25	2.63	44.8	2.5	183	230	246	279	----	----	----	----	82.5	----
99	84	58	36	23	12	7	4	2	1	31	57	12	2.68	31.6	2.8	244	360	310	374	1130	2310	1474	2385	96.2	96.8
100	99	82	36	20	7	4	3	4	----	12	81	7	2.53	38.7	2.2	146	238	260	314	----	----	----	----	75.6	----
101	56	14	4	2	1	----	----	----	----	68	31	1	2.51	34.1	2.6	203	271	246	316	1535	2480	1750	2630	87.5	94.5
102	----	----	----	96	87	48	22	12	3	----	13	87	2.90	40.1	1.7	155	222	227	347	926	1510	1910	3380	64.1	44.7
103	93	77	50	27	17	10	6	4	2	15	68	17	2.71	35.1	2.4	184	272	271	366	1495	2117	1620	3402	74.3	62.1
104	----	----	----	94	67	40	13	6	----	----	33	67	2.70	41.2	1.5	127	181	261	374	517	757	1414	2190	48.5	34.5
105	98	92	65	38	24	13	7	4	----	3	73	24	2.71	34.8	2.2	125	244	262	380	1093	1693	1911	2786	64.2	60.8
106	72	42	28	19	13	8	5	3	----	46	41	13	2.63	38.1	4.3	306	424	300	381	2790	4008	1712	2607	111.7	153.8
107	97	91	72	63	38	17	4	2	----	7	55	38	2.63	41.2	1.7	----	----	----	----	----	1375	----	2955	----	46.6
108	69	42	22	15	8	5	2	----	----	31	61	8	2.63	31.7	3.9	----	----	----	----	----	2723	----	2824	----	96.6
109	100	92	80	70	55	22	8	4	----	6	39	55	2.64	38.7	1.7	191	279	342	428	3116	3600	3487	3910	65.2	92.1
110	99	71	43	27	17	8	5	4	2	14	69	17	2.55	44.7	2.6	134	224	272	377	789	1988	1904	2410	59.4	58.2

[a] Proportion of mortar mixture by weight 1 : 2.
[b] Tested at the age of 18 days and 30 days, respectively.
[c] Tarlac sand was used instead of Ottawa sand.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screen.									Three-screen analysis. Per cent particles.			Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar).				Compressive strength in pounds per square inch (1:3 mortar).				Strength at the age of 28 days. $\frac{\text{Specimen}}{\text{standard}} \times 100$.	
																Sand specimens.		Standard sand.		Sand specimens.		Standard sand.			
	10	20	30	40	50	60	80	100	200	Coarse.	Medium.	Fine.				7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	Tensile.	Compressive.
111	72	31	9	3	2	1	----	----	----	55	43	2	2.37	50.3	2.6	244	281	257	354	1534	1998	1783	2328	79.4	85.8
112	87	65	41	32	11	6	3	1	0.5	27	62	11	2.39	37.7	2.4	192	273	238	318	834	1870	1427	2130	86.1	87.8
113	47	8	4	3	2	2	2	15	1	78	20	2	2.35	40.2	2.5	231	286	263	329	1258	1607	1427	2130	87.1	75.2
114	60	34	18	13	8	4	2	2	1	56	36	8	2.46	36.1	4.2	204	261	263	329	1059	1376	1427	2130	79.5	64.5
115	63	32	17	10	4	4	3	2	1	58	38	4	2.41	44.2	3.7	266	314	257	354	783	1878	1584	2804	88.6	66.8
116	63	28	13	7	4	3	2	1	0.5	60	36	4	2.33	34.3	3.2	240	287	261	321	602	1113	657	1824	89.[illegible]	61.1
117	82	38	16	8	5	3	2	1	----	40	55	5	2.30	32.1	2.6	192	303	275	389	1390	2220	1786	2410	78.1	92.1
118	62	17	6	2	2	1	1	0.5	----	68	30	2	1.97	37.3	2.2	161	234	231	278	743	1250	1729	2002	84.1	61.8
119	71	29	9	4	1	0.5	----	----	----	57	42	1	2.14	------	2.6	----	[d] 327	----	[d] 340	------	[d] 3845	------	[d] 4288	96.3	90.1
120	99	97	40	7	2	----	----	----	----	2	96	2	------	------	------	213	254	307	365	1548	2020	1657	2400	69.5	84.1
121	45	23	13	10	7	4	3	2	1	70	23	7	------	------	------	435	502	307	365	3032	3974	1657	2400	137.1	165.1
122	98	83	50	26	16	10	7	4	2	7	77	16	2.67	30.2	2.3	218	331	281	352	1682	2117	1898	2759	94.2	76.7
123	98	93	81	60	31	17	10	6	1	6	63	31	2.77	38.5	2.1	219	323	237	384	1468	2550	2227	3770	84.1	67.6
124	78	57	38	25	13	5	2	----	----	32	55	13	2.57	41.9	4.1	154	239	294	369	946	1677	1488	2844	65.1	58.8
125	94	65	16	7	3	2	2	2	----	25	72	3	2.63	------	1.7	188	249	219	325	------	------	------	------	76.5	------
126	83	64	48	34	22	12	8	6	2	28	50	22	2.62	30.5	3.1	267	373	274	339	2375	3313	2274	2857	110.1	116.1
127	60	28	17	12	8	5	4	3	2	40	52	8	2.67	30.1	5.1	159	330	199	337	1532	1997	1434	2041	98.1	97.7
128	95	83	62	37	19	10	6	3	1	11	70	19	2.55	40.7	1.2	123	221	278	320	743	1471	1664	2972	69.1	49.5
129	57	41	28	16	5	4	3	2	1	61	34	5	2.60	27.1	3.9	237	411	249	379	2155	2683	2249	2658	108.1	101.2
130	68	43	28	19	11	7	5	4	2	31	58	11	2.64	30.1	4.1	151	284	199	337	1240	2180	1434	2041	84.5	106.5
131	----	----	----	----	----	----	----	----	----	------	------	------	------	------	------	263	363	----	----	------	------	------	------	------	------
132	94	75	53	37	28	19	14	8	3	17	55	28	2.69	37.3	3.1	289	414	254	310	1523	2403	1856	2108	133.1	114.1
133	75	61	33	14	8	6	3	2	1	33	59	8	2.65	39.1	2.3	198	268	278	366	2006	2641	2517	3811	73.1	69.3

134	98	70	14	3	2	2	1	1	----	17	81	2	2.68	39.3	1.3	200	261	252	340	798	1553	1364	2271	77.1	68.4
135	97	87	26	9	7	4	3	2	1	6	87	7	2.65	41.1	1.4	226	240	258	361	1784	2540	2504	3865	66.5	65.8
136	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	172	244	----	----	----	----	----	----	----	----
137	98	96	81	37	20	7	5	2	1	2	78	20	----	----	----	----	----	----	----	----	----	----	----	----	----
138	97	85	50	23	10	4	3	2	1	7	83	10	2.70	35.1	1.6	237	258	253	316	1635	2176	1829	2525	81.6	86.3
139	97	84	73	63	32	12	3	2	----	11	57	32	2.67	38.6	1.7	226	292	254	310	1570	2103	1856	2108	94.2	99.9
140	64	31	14	7	4	3	2	1	0.5	57	39	4	2.62	39.7	3.3	272	371	279	369	1812	3425	1733	3127	100.1	109.5
141	87	43	22	7	3	2	2	2	----	37	60	3	2.65	32.4	2.5	213	260	258	352	1779	2350	2053	2845	74.1	82.6
142	82	57	40	26	7	5	3	2	----	34	59	7	2.70	36.1	3.1	224	321	254	412	1600	2618	1740	3228	78.1	81.2
143	99	87	68	47	35	18	9	6	1	10	55	35	2.75	39.6	2.3	185	231	268	357	2020	2715	2240	2878	65.1	94.4
144	86	12	5	3	2	1.5	1	0.5	----	67	31	2	2.63	44.1	1.7	227	344	255	289	1759	2356	1872	3186	119	74.1
145	80	53	8	1	----	----	----	----	----	36	64	----	2.66	33.4	1.8	268	380	241	340	810	1660	1008	1320	112.1	126.1
146	97	85	58	43	22	15	9	7	----	11	67	22	2.70	36.8	2.8	----	----	----	----	----	----	----	----	----	----
147	94	79	45	14	3	2	1	0.5	----	12	85	3	2.70	35.1	1.6	225	332	235	326	1340	2230	1790	2370	102.1	94.1
148	94	67	34	15	7	4	3	2	2	20	73	7	2.53	38.1	2.1	146	228	215	339	759	1666	1725	2177	67.3	76.6
149	72	29	10	5	5	2	1	0.5	----	52	43	5	2.48	34.3	2.5	211	310	234	328	1194	2608	1650	2375	94.5	109.8
150	92	76	56	33	19	11	7	5	2	16	65	19	2.73	37.6	2.4	199	328	266	422	1220	2385	1540	2981	77.8	80.1
151	98	96	88	68	28	14	9	5	1	3	69	28	2.75	40.1	1.7	142	230	262	331	697	1356	1724	2370	69.5	57.2
152	92	82	65	43	30	14	7	3	1	12	58	30	2.75	34.9	2.1	212	320	276	352	1339	2325	1772	3040	91.1	76.5
153	98	97	88	58	30	12	6	3	1	3	67	30	2.77	39.1	1.8	135	239	262	331	691	1275	1724	2370	72.2	53.8
154	95	87	68	47	28	11	6	4	2	8	64	28	2.60	39.0	2.1	142	285	236	349	698	1526	1410	2316	81.6	65.9
155	97	84	70	57	30	15	7	3	----	13	57	30	2.62	----	1.9	260	310	243	359	----	----	----	----	86.4	----
156	96	89	75	66	35	20	1	1	----	7	58	35	2.61	40.1	2.1	231	324	265	341	----	----	----	----	95.1	----
157	89	75	55	36	24	15	9	7	2	18	58	24	2.63	27.4	2.8	200	349	276	355	1293	2415	1601	2311	98.4	104.5
158	87	67	52	34	25	17	13	11	8	23	52	25	2.63	39.1	4.7	240	359	253	363	1358	2137	1729	2482	99.1	86.1
159	83	67	53	37	25	14	8	7	2	24	51	25	2.65	25.9	3.1	180	317	253	341	1433	2566	1698	2512	93.1	102.1
160	91	74	48	27	13	7	3	2	1	17	70	13	2.65	36.7	2.3	218	328	284	407	1384	2665	1921	2973	80.7	89.7
161	78	61	44	28	20	13	10	8	2	30	50	20	2.73	45.7	3.7	322	467	250	351	1727	3869	1616	2505	133.1	154.3
162	75	42	27	16	10	7	4	3	2	44	46	10	----	----	3.8	203	291	221	345	1858	3012	1481	3144	86.8	95.6
163	91	41	16	11	5	2	1	1	----	41	54	5	2.58	37.6	2.6	274	338	275	320	----	----	----	----	105.6	----
164	57	26	9	6	3	2	2	1	----	62	35	3	2.22	36.1	2.9	242	275	304	373	1345	1665	1456	2088	73.8	79.8
165	90	64	47	29	16	4	2	1	----	22	62	16	----	----	----	247	330	259	392	833	1613	1362	2257	84.7	71.6
166	77	39	18	11	6	3	2	2	----	48	46	6	2.45	45.1	3.1	239	321	275	320	----	----	----	----	100.1	----

[d] Mortar mixture by weight 1 : 2.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screen.									Three-screen analysis. Per cent particles.			Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar).				Compressive strength in pounds per square inch (1:3 mortar).				Strength at the age of 28 days. $\frac{\text{Spec'men}}{\text{standard}} \times 100$.	
																Sand specimens.		Standard sand.		Sand specimens.		Standard sand.			
	10	20	30	40	50	60	80	100	200	Coarse.	Medium.	Fine.				7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	Tensile.	Compressive.
167	98	82	37	18	8	2	1	1	----	10	87	3	2.58	44.5	2.1	214	259	275	320	------	------	------	------	81.1	--------
168	73	42	25	15	10	6	4	3	1	45	45	10	2.63	40.1	3.6	305	310	237	311	1510	2142	1287	1949	99.8	110.1
169	99	64	38	23	14	7	5	3	----	18	68	14	2.64	45.7	2.7	111	164	244	350	742	1485	1803	2397	46.8	62.1
170	72	27	10	6	3	3	2	2	1	43	54	3	2.62	30.1	2.3	171	283	313	325	1630	2516	1490	2218	87.1	114.1
171	78	10	5	4	3	2	2	1	0	64	33	3	2.70	37.9	1.7	290	370	254	354	3049	4721	2050	2704	104.5	174.6
172	83	59	42	18	10	7	5	3	2	32	58	10	2.54	29.4	2.6	301	386	216	338	1772	2654	1482	2473	114.2	107.1
173	90	68	56	28	9	8	7	4	3	32	59	9	2.44	41.1	2.7	168	244	225	313	993	1960	1433	1996	78.1	98.2
174	75	30	12	6	4	2	1	0.5	----	50	46	4	2.77	43.1	2.6	258	347	281	388	2370	4390	2230	3738	89.5	117.3
175	88	57	33	22	17	12	8	7	4	30	53	17	2.67	33.4	4.1	244	355	249	337	1469	2724	1454	2174	105.2	125.3
176	78	50	28	17	12	9	6	3	----	37	51	12	2.65	29.3	3.6	256	367	333	423	1657	2640	1660	2211	86.8	119.3
177	90	65	48	36	28	19	12	8	3	23	49	28	2.66	34.1	4.1	189	249	246	343	1258	2350	1794	2742	72.6	85.7
178	97	85	65	43	25	12	5	3	1	8	67	25	2.64	41.8	2.1	118	169	246	343	650	1235	1794	2742	49.3	45.1
179	97	86	68	50	37	22	14	8	3	6	57	37	2.76	41.9	2.7	140	220	246	343	856	1415	1794	2742	64.2	51.6
180	99	92	60	43	15	7	4	2	----	7	78	15	2.73	49.8	2.1	-----	-----	-----	-----	------	------	------	------	------	--------
181	98	96	95	93	80	50	22	8	2	3	17	80	2.65	47.1	1.7	193	291	277	400	1147	1338	2173	3452	73.1	38.7
182	98	94	86	68	44	27	17	8	2	4	52	44	2.85	40.2	2.1	164	214	243	343	715	1420	1794	2742	62.4	51.7
183	98	92	61	36	22	12	7	4	2	3	75	22	2.83	36.7	2.1	175	264	289	414	988	2359	1819	2678	63.8	88.2
184	75	57	48	38	29	21	12	8	2	34	37	29	2.80	31.4	6.3	201	321	246	343	1810	3370	2150	3800	93.8	88.7
185	96	80	57	37	23	11	7	3	2	10	67	23	2.49	37.6	2.5	58	102	246	343	375	515	1794	2742	30.1	18.9
186	98	97	92	76	56	20	6	3	----	2	42	56	2.82	44.6	1.4	190	266	270	384	1245	1660	1970	2935	69.3	56.6
187	87	64	41	27	18	11	7	5	2	23	59	18	2.83	45.1	3.2	230	322	262	367	1426	2656	1600	2500	87.8	106.1
188	93	74	47	28	16	9	6	3	2	16	68	16	2.78	37.1	2.5	119	202	246	343	1112	2140	1794	2742	59.1	78.1
189	77	52	36	23	14	7	3	2	1	36	50	14	2.78	34.1	5.1	223	281	246	343	1655	2900	1794	2742	82.1	105.7

190	87	74	63	57	52	46	23	13	----	21	27	52	2.72	------	1.9	231	340	327	436	2801	3694	3316	3612	78.1	102.4
191	----	97	87	67	26	13	8	5	2	2	72	26	2.64	42.1	1.6	148	190	234	318	656	999	1690	2445	59.8	40.8
192	100	94	68	38	21	8	5	3	2	4	75	21	2.69	41.1	2.1	145	210	300	342	876	1194	1476	2896	61.4	41.3
193	----	----	97	92	85	70	25	7	2	0	15	85	2.68	38.3	1.1	134	163	264	334	606	945	1543	2481	48.8	38.1
194	99	96	88	76	57	21	14	8	2	3	40	57	2.64	43.3	2.2	125	171	300	342	515	722	1516	2002	50.1	36.1
195	----	98	96	86	55	17	7	3	2	0	45	55	2.69	37.6	1.3	99	160	264	334	595	1136	1543	2481	48.1	45.7
196	----	98	94	86	74	45	20	12	3	0	26	74	2.71	39.3	1.8	94	128	264	334	519	925	1543	2481	38.4	37.2
197	----	97	78	48	27	13	9	6	2	2	71	27	2.66	41.1	1.9	139	185	234	318	767	1164	1690	2445	58.2	47.7
198	76	37	11	5	2	1	0.5	----	----	48	50	2	2.74	36.2	2.4	231	----	----	----	------	3946	------	5004	------	78.4
199	98	84	45	20	11	7	4	3	1	8	81	11	2.63	41.3	2.1	138	228	246	343	756	1950	1794	2742	66.5	71.1
200	88	67	52	42	32	18	12	7	2	23	45	32	2.70	36.1	3.5	257	368	252	353	1367	2665	1747	2596	104.3	102.8
201	98	81	36	22	13	8	3	1	----	11	76	13	2.70	35.1	2.4	314	428	313	403	2520	3320	2586	3100	106.2	107.2
202	----	99	97	93	87	72	48	25	1	0	13	87	2.73	41.1	1.7	110	188	256	334	400	887	1700	2400	56.4	36.9
203	96	74	52	27	15	8	5	4	1	1.6	69	15	2.75	37.9	2.2	234	320	256	334	1789	2650	1700	2400	96.1	110.3
204	95	79	48	28	18	12	7	5	----	14	68	18	2.55	39.1	2.7	220	314	315	386	1225	1731	1970	2340	81.2	74.2
205	98	88	67	43	24	12	8	5	2	4	72	24	2.76	41.3	2.3	196	293	247	342	971	2008	1663	2680	85.8	74.7
206	93	69	45	22	11	6	3	2	----	17	72	11	2.69	42.2	2.3	124	196	221	326	792	1711	1623	2300	60.2	74.5
207	74	43	22	8	3	2	----	----	----	44	53	3	2.61	34.1	2.7	166	283	227	347	1440	2080	1910	3380	81.5	61.5
208	90	58	31	15	7	2	1	----	----	25	68	7	2.50	38.1	2.3	182	216	361	389	834	1480	1868	2580	55.5	57.4
209	99	86	52	27	13	8	6	3	2	7	80	13	2.71	44.2	2.1	----	----	----	----	----	----	----	----	----	----
210	98	84	48	29	18	10	5	2	0	9	74	18	2.63	41.6	2.4	----	----	----	----	----	----	----	----	----	----
211	40	10	5	3	2	1	----	----	----	78	20	2	2.70	32.9	2.9	394	589	335	458	2608	5508	1508	2827	128.1	195.1
212	97	88	71	45	25	13	8	5	1	8	67	25	2.65	33.7	2.1	190	315	235	371	1475	2391	2113	3180	85.1	75.2
213	98	73	40	23	9	3	2	1	0	15	76	9	2.79	38.1	2.1	217	338	252	308	1644	2322	1356	2235	109.8	104.1
214	98	88	66	47	27	13	7	3	1	5	68	27	2.51	48.1	2.2	280	354	512	522	2255	3305	4370	5080	68.1	65.2
215	82	50	32	18	12	6	4	3	1	36	52	12	2.58	31.1	3.3	286	302	272	342	2154	3016	2065	2609	88.3	115.6
216	98	92	76	61	28	15	7	1	----	5	67	28	2.64	36.2	1.8	----	----	----	----	2559	4327	3201	4637	------	93.7
217	95	89	80	52	27	12	4	2	1	9	64	27	2.71	38.7	1.9	247	342	281	323	----	----	----	----	106.0	----
218	72	54	35	22	13	8	7	4	2	38	49	13	2.80	32.1	3.7	361	528	288	410	2350	3398	1800	2693	112.9	112.6
219	97	91	67	44	18	8	4	2	1	6	78	18	2.60	35.1	1.7	166	290	288	410	741	1433	1800	2693	70.7	53.3
220	100	97	78	60	28	10	4	3	1	2	70	28	2.20	41.6	2.5	160	217	281	343	774	938	1279	2030	63.3	46.1
221	99	94	86	74	56	50	25	6	2	3	41	56	2.64	36.1	1.6	107	263	245	345	690	1610	1654	2639	76.2	61.1
222	77	33	21	16	12	8	7	4	2	46	42	12	2.64	33.1	4.1	246	345	245	345	1786	3188	1654	2639	100.0	121.2
223	93	27	4	3	2	2	2	1	0	40	58	2	2.59	36.1	1.7	166	192	245	345	1193	2050	1654	2639	55.6	78.1
224	97	28	16	12	10	7	5	4	2	40	50	10	2.58	41.1	3.3	101	228	245	345	812	1800	1654	2689	66.1	68.3

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screen.									Three-screen analysis. Per cent particles.			Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar).				Compressive strength in pounds per square inch (1:3 mortar).				Strength at the age of 28 days. $\frac{\text{Specimen}}{\text{standard}} \times 100$.	
																Sand specimens.		Standard sand.		Sand specimens.		Standard sand.			
	10	20	30	40	50	60	80	100	200	Coarse.	Medium.	Fine.				7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	Tensile.	Compressive.
225	84	57	41	28	22	17	12	8	1	34	44	22	2.50	39.9	4.8	147	210	317	356	562	821	1161	1731	59.1	47.4
226	67	38	24	16	11	6	4	2	1	50	39	11	2.63	35.1	4.3	264	341	258	353	1934	3164	1572	2729	96.7	116.1
227	65	17	8	7	5	4	3	2	1	68	27	5	2.63	35.9	2.5	285	405	277	404	2286	3335	1594	3247	100.1	102.6
228	58	13	5	3	2	1	0.5	----	----	73	25	2	2.64	34.4	2.3	321	432	277	404	2633	3836	1594	3247	107.1	118.1
229	86	72	57	50	35	25	16	9	----	24	41	35	2.57	36.8	3.8	170	220	263	370	544	1202	1427	2130	59.4	56.4
230	36	74	10	8	7	5	3	3	0	79	14	7	2.59	33.7	4.8	245	374	263	370	1268	2294	1427	2130	101.1	107.8
231	89	53	20	7	3	2	1	----	----	23	74	3	2.52	36.4	2.1	154	214	259	367	631	1254	1784	2700	58.3	46.5
232	65	19	7	4	3	2	2	1	----	62	35	3	2.63	35.7	2.4	339	405	245	385	2235	3908	1444	2241	105.2	174.1
233	86	59	38	24	10	5	2	1	----	28	62	10	2.61	45.7	2.4	209	298	270	334	317	661	912	1450	89.5	45.5
234	84	57	38	25	16	10	6	3	1	32	52	16	2.66	39.1	3.2	243	358	273	334	738	1298	912	1450	107.1	89.5
235	77	30	13	7	5	3	2	2	1	44	51	5	2.64	33.2	2.2	231	364	264	346	1508	2574	1681	2189	105.2	117.6
236	22	10	7	5	4	3	2	1	----	87	9	4	2.78	36.8	3.4	339	509	261	374	2657	3760	1414	2190	136.1	171.8
237	93	62	30	16	8	5	4	3	2	20	72	8	2.45	37.1	2.2	238	301	361	389	1360	2020	1868	2580	77.5	78.4
238	90	54	24	12	6	2	1	----	----	29	65	6	2.50	43.2	2.7	222	294	289	392	1606	2708	1886	2730	75.1	99.3
239	98	82	54	20	12	7	2	1	----	8	80	12	2.67	42.8	2.1	176	251	243	370	1154	1722	1584	2546	67.7	67.6
240	89	56	24	12	8	6	4	3	2	24	68	8	2.52	36.1	2.4	252	315	361	389	1270	1780	1868	2580	81.1	69.1
241	97	72	46	28	17	8	5	3	1	13	70	17	2.51	44.7	2.6	102	202	229	375	469	1184	1444	2365	54.1	50.2
242	96	68	30	15	9	6	4	3	2	17	74	9	2.52	38.7	2.1	127	258	215	339	768	1632	1728	2177	76.2	75.1
243	91	66	37	22	13	7	4	2	2	21	66	13	2.55	40.7	2.7	136	211	241	392	695	1424	1637	2451	54.1	58.1
244	96	62	31	16	7	4	3	2	1	21	72	7	2.58	34.1	2.1	156	262	228	330	1082	1983	1328	2263	79.4	87.5
245	82	47	20	10	5	3	2	2	1	18	77	5	2.62	39.1	2.6	242	336	320	415	1690	3260	2380	3610	81.1	90.5
246	98	94	82	65	47	23	13	8	3	4	49	47	2.89	45.1	2.1	212	344	251	370	880	1917	1811	2762	93.1	69.3
247	83	55	29	14	8	4	3	2	----	30	62	8	2.70	42.1	2.5	253	375	270	392	1515	3509	1913	3777	95.6	95.2

248	92	64	46	33	26	17	11	8	1	24	50	26	2.68	38.6	3.8	183	305	235	310	1564	2389	1670	2248	98.5	106.2
249	96	68	40	22	12	7	4	3	2	17	71	12	2.57	40.1	2.5	197	298	286	403	1329	1983	2100	2722	73.9	72.8
250	84	56	37	23	14	7	4	3	1	31	55	14	2.49	38.1	3.2	188	322	260	389	1375	2720	1769	3040	82.7	89.5
251	78	49	26	15	9	6	3	1	----	38	53	9	2.61	40.3	3.4	197	312	316	402	779	2199	1704	2425	77.7	90.5
252	96	71	37	18	12	6	4	3	2	15	73	12	2.55	36.1	2.5	159	232	255	365	1313	1832	1920	2777	63.6	66.1
253	87	65	47	35	25	17	13	10	5	22	53	25	2.58	32.9	2.8	130	234	255	365	1180	2060	1920	2777	64.1	74.2
254	97	77	44	27	15	9	4	3	2	12	73	15	2.62	45.7	2.5	90	162	283	364	725	1181	1523	2861	44.3	41.3
255	78	57	41	29	19	11	6	3	0	33	48	19	2.59	38.7	3.7	225	352	310	432	1818	2405	2631	3428	81.4	70.2
256	85	66	47	34	22	12	8	5	----	26	52	22	2.56	40.3	2.9	216	309	265	325	854	1149	1648	2618	95.1	44.1
257	95	74	54	36	24	13	7	4	1	14	62	24	2.61	35.4	2.6	235	350	277	364	1604	2930	1517	2928	96.2	100.1
258	84	62	43	34	22	12	7	5	2	29	49	22	2.62	30.6	3.4	218	309	251	325	1505	2597	1560	2464	95.1	105.2
259	97	81	50	28	16	7	3	2	1	8	76	16	2.65	38.7	2.2	217	338	265	389	1180	2538	1600	2606	86.8	97.3
260	95	77	38	13	10	2	1	1	----	5	85	10	2.65	47.1	1.8	183	313	262	367	1134	2003	1600	2500	85.3	80.3
261	94	77	56	37	24	13	7	4	2	13	63	24	2.54	32.2	2.5	193	268	277	364	1417	2545	1517	2928	73.5	86.8
262	98	94	82	60	32	12	4	3	2	4	64	32	2.76	37.1	2.7	221	286	257	312	2150	2550	1700	3040	91.5	84.1
263	95	74	48	30	20	11	7	4	2	13	67	20	2.70	39.1	1.8	185	281	257	312	1270	2000	1700	3040	90.1	65.7
264	87	60	37	18	10	4	2	1	----	27	63	10	2.91	33.7	2.7	274	389	255	338	1536	3631	2089	2703	115.1	134.1
265	95	80	50	18	13	8	6	3	2	11	76	13	2.67	31.3	2.1	231	333	233	347	1343	2146	1718	2527	96.1	85.1
266	88	66	38	18	7	3	2	1	1	18	75	7	2.83	33.1	2.3	214	279	255	338	1571	2706	2089	2703	82.5	100.1
267	93	70	43	17	7	3	2	2	1	17	76	7	2.71	30.2	2.1	216	300	253	315	1959	3083	1829	2525	95.2	122.1
268	98	94	70	37	18	9	6	4	2	2	80	18	2.68	32.1	2.1	218	279	246	356	1198	1800	1562	2610	78.6	69.1
269	98	89	73	45	23	12	8	7	5	7	70	23	2.77	34.8	2.1	170	235	208	290	923	1801	1375	2512	81.1	71.8
270	95	78	66	54	30	10	3	----	----	15	55	30	2.58	41.1	1.8	139	204	223	338	803	1311	1636	2622	60.1	50.1
271	92	64	27	12	5	2	2	2	1	22	73	5	2.77	33.8	2.1	207	368	267	419	1720	3012	2506	4197	88.1	72.1
272	97	90	79	36	25	14	10	7	2	4	71	25	2.66	32.7	2.1	175	284	247	368	1102	1900	1799	2585	77.2	73.5
273	97	78	44	17	7	4	2	1.5	0.5	12	81	7	2.60	32.1	1.7	213	277	275	351	1225	2028	1478	2353	79.1	86.4
274	100	97	77	35	17	7	4	2	1	0	83	17	2.72	33.4	1.6	202	278	260	376	1911	2796	2758	3411	74.1	80.7
275	100	92	77	60	45	12	7	3	2	5	50	45	2.71	31.5	1.6	181	271	281	352	1324	2188	1897	2595	77.1	84.4
276	97	75	36	12	4	3	2	2	2	10	86	4	2.73	33.1	1.5	196	308	243	326	1791	2824	2139	3934	94.5	72.1
277	93	78	47	29	18	7	6	4	2	15	67	18	2.68	32.9	2.4	223	322	234	355	1343	2481	1893	2406	90.8	103.1
278	98	95	83	59	33	12	5	3	1	3	64	33	2.68	42.1	1.8	201	248	265	339	946	1420	1520	2820	73.3	50.4
279	98	75	45	27	18	11	8	7	3	10	72	18	2.80	40.1	2.8	200	314	244	381	1414	2340	1848	2610	82.5	89.5
280	98	90	67	30	15	7	4	2	1	5	80	15	2.70	31.9	1.7	164	218	230	320	995	1749	1535	2311	68.1	75.6
281	81	46	31	23	12	7	5	4	3	43	45	12	2.78	29.1	2.1	181	311	232	334	1887	3418	1677	2340	93.3	146.1
282	96	62	31	17	8	4	3	2	----	20	72	8	2.69	34.9	2.2	148	332	227	273	1036	2558	1394	2220	123.1	115.1

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screen.									Three-screen analysis. Per cent particles.			Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar).				Compressive strength in pounds per square inch (1:3 mortar).				Strength at the age of 28 days. $\frac{\text{Specimen}}{\text{standard}} \times 100$.	
																Sand specimens.		Standard sand.		Sand specimens.		Standard sand.			
	10	20	30	40	50	60	80	100	200	Coarse.	Medium.	Fine.				7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	Tensile.	Compressive.
283	99	91	65	28	8	3	2	1	----	4	88	8	2.71	38.4	1.4	148	249	287	360	1031	1999	1567	2950	69.2	67.7
284	94	72	40	16	7	4	3	2	----	16	77	7	2.76	35.1	2.1	172	218	247	341	1410	2358	1770	2290	64.1	103.1
285	98	92	63	32	14	7	5	3	2	5	81	14	2.71	33.7	1.8	141	242	210	322	860	1715	1457	2627	75.2	65.2
286	98	93	72	30	17	8	4	3	2	4	79	17	2.73	40.3	1.7	186	240	252	344	1193	1837	1715	2473	70.1	74.2
287	100	98	77	45	24	12	3	1	0	2	74	24	2.72	34.1	1.8	172	242	260	341	982	1735	1596	2217	71.1	79.1
288	100	95	66	31	15	7	5	2	1	3	82	15	2.77	33.2	1.7	185	269	257	324	1101	1978	1478	2253	83.1	87.7
289	98	89	62	25	7	3	2	2	1	5	88	7	2.73	33.5	1.4	175	285	223	549	696	2871	1229	4734	51.9	60.8
290	93	75	43	20	12	6	3	2	1	20	68	12	2.67	32.6	2.1	189	331	242	341	1756	2714	1902	3023	97.2	89.8
291	83	47	29	16	6	4	2	2	1	40	54	6	2.71	29.1	3.0	326	432	251	373	2759	3233	2260	3406	115.6	95.1
292	76	24	2	1	----	----	----	----	----	57	43	0	2.17	51.5	2.3	[a] 332	[a] 378	----	----	[a] 3140	[a] 3700	----	----	----	----
293	84	61	36	25	16	8	3	2	----	28	56	16	2.92	38.6	2.8	335	428	367	351	1662	2164	2030	2654	122.1	81.7
294	83	52	34	18	10	4	3	2	----	37	53	10	2.63	32.1	3.1	296	470	259	371	1493	2577	1901	2940	124.1	87.8
295	86	74	60	42	27	12	7	3	----	20	53	27	2.58	37.4	2.3	175	265	310	432	803	1439	2630	3428	60.5	42.1
296	91	77	59	38	23	8	5	3	2	18	59	23	2.51	39.1	2.1	194	287	266	367	926	1649	2102	2491	78.2	66.2
297	89	81	68	46	29	13	6	3	2	14	57	29	2.62	34.5	2.1	160	260	266	367	801	1456	2102	2491	70.8	58.5
298	66	42	28	17	10	5	3	2	1	47	43	10	2.77	31.9	4.1	279	374	280	334	1704	3565	1676	2472	112.1	144.5
299	86	66	43	23	13	7	2	1	----	25	62	13	2.67	34.8	2.3	174	256	280	334	957	1988	1676	2472	107.1	80.5
300	87	65	42	25	12	7	3	1	----	23	65	12	2.69	37.1	2.5	211	315	211	343	1418	2527	1448	2807	92.1	90.1
301	70	43	24	13	8	4	3	2	1	46	46	8	2.65	34.1	3.4	209	325	255	349	1343	2807	1393	3022	91.1	93.5
302	66	26	----	----	----	----	----	----	----	----	----	----	2.88	56.1	----	169	----	197	----	[a] 2087	----	----	----	----	----
303	96	89	77	68	48	26	9	3	----	8	44	48	2.60	----	1.7	----	[a] 270	----	[a] 340	----	[a] 3245	----	[a] 4288	79.4	75.8
304	87	66	52	35	20	11	7	4	1	24	56	20	2.43	27.5	2.7	192	252	212	302	1200	1660	1650	2465	83.5	67.2
305	77	50	30	17	11	7	6	4	2	40	49	11	2.78	30.2	3.4	262	429	258	334	2161	3408	2385	3228	127.1	105.3

306	78	39	22	13	9	7	4	3	2	44	47	9	2.67	29.7	3.5	276	400	282	333	1565	2815	1714	2318	120.1	121.6
307	85	75	61	38	20	12	7	4	2	26	54	20	2.63	31.6	2.6	222	345	236	343	1670	2620	1900	2550	101.1	104.1
308	78	48	28	18	12	8	5	4	2	40	48	12	2.65	26.1	3.7	192	312	235	330	1860	3374	1896	2671	94.7	126.3
309	87	66	45	26	17	10	7	5	2	23	60	17	2.65	27.5	2.9	171	277	235	330	1260	2094	1896	2671	84.1	78.4
310	88	67	43	26	17	10	7	5	2	25	58	17	2.66	28.7	2.8	195	289	235	330	1442	2691	1896	2671	87.5	100.8
311	81	56	37	20	10	4	2	1	0	32	58	10	2.68	26.9	2.8	227	314	235	330	1848	2749	1896	2671	95.2	103.1
312	78	49	27	13	7	3	2	1	----	36	57	7	2.60	32.1	2.9	248	318	249	318	1430	2210	1700	2460	100.0	90.1
313	63	34	18	12	7	4	3	2	1	53	40	7	2.69	32.1	4.3	281	372	298	390	2180	2750	2190	3450	95.1	80.1
314	71	46	27	15	9	6	3	2	----	44	47	9	2.64	32.5	3.8	203	317	224	340	1117	2510	1767	2932	93.1	85.6
315	62	26	12	17	5	3	2	1	----	57	38	5	2.66	34.5	3.2	251	405	266	391	1235	3340	1387	3045	104.1	109.7
316	77	39	17	7	3	2	----	----	----	46	51	3	2.65	35.5	2.7	267	343	254	370	1604	3046	1673	2435	93.1	125.1
317	87	70	54	41	32	26	17	14	10	34	34	32	2.71	34.8	6.5	276	364	276	350	2414	2947	2218	3506	104.1	84.1
318	94	63	20	10	5	2	1	----	----	22	73	5	2.58	44.2	1.7	211	280	281	354	1534	1929	2028	3626	70.1	52.8
319	84	54	47	36	25	17	13	9	3	38	47	25	2.67	35.1	4.6	315	395	281	398	2106	3558	2026	2626	99.5	135.2
320	98	89	60	32	18	8	3	2	----	5	77	18	2.71	35.6	2.1	-----	340	-----	400	------	1649	------	2340	85.1	70.3
321	76	47	27	15	13	7	5	4	2	41	46	13	2.84	37.5	3.3	257	381	274	340	1707	3375	1678	2426	112.1	139.2
322	80	42	22	12	7	4	3	2	----	44	49	7	2.42	40.3	3.1	114	189	274	340	508	980	1678	2426	55.6	40.4
323	99	91	65	42	29	18	12	5	----	3	68	29	2.87	37.6	2.4	263	348	274	340	2088	3055	1678	2426	102.3	126.1
324	52	26	7	2	1	----	----	----	----	63	36	1	2.46	37.1	3.4	130	252	229	342	972	1331	1965	3011	73.5	44.3
325	78	56	33	21	12.	7	4	3	----	32	56	12	2.50	37.1	3.1	152	276	229	342	984	1699	1965	3011	80.8	56.4
326	94	44	7	2	0	----	----	----	----	30	70	0	2.94	35.1	1.7	196	294	274	340	1625	2530	1678	2426	86.5	104.2
327	84	42	25	17	13	8	7	5	2	41	46	13	2.83	37.9	3.9	217	340	274	340	1601	2775	1678	2426	100.0	114.2
328	100	99	98	95	77	47	25	3	----	-------	23	77	2.61	46.9	1.5	161	206	253	300	------	------	------	------	68.7	--------
329	69	22	2	1	0	0.1	----	----	----	62	38	0	2.77	39.1	2.3	330	457	326	330	1392	4124	1735	2975	138.2	138.6
330	98	71	26	10	3	2	1	----	----	18	79	8	2.68	43.3	1.8	176	246	262	330	------	------	------	------	74.5	--------
331	96	79	40	22	12	7	4	3	2	12	76	12	2.64	41.5	2.3	164	262	247	344	1037	1790	1995	2970	76.2	60.3
332	94	43	17	7	4	3	2	2	1	30	66	4	2.77	35.1	2.5	292	365	259	369	1810	3155	1673	2377	99.1	132.6
333	98	63	32	14	6	3	2	1	----	12	82	6	2.62	38.1	1.8	239	320	260	344	1520	2279	1920	2830	93.1	80.5
334	100	95	78	55	33	7	3	2	1	3	64	33	2.89	31.4	1.6	228	309	269	373	1550	2246	2107	2846	82.7	79.1
335	67	18	5	3	2	2	1	0.5	----	60	38	2	2.63	36.1	2.3	230	355	207	337	1638	2915	1525	2224	105.2	131.1
336	97	68	33	17	9	3	2	1	----	16	75	9	2.99	32.9	2.3	222	373	207	337	1693	3269	1525	2224	111.6	146.7
337	92	75	24	15	8	4	3	2	----	14	78	8	2.66	38.4	2.1	205	291	285	362	1068	1849	1783	3136	80.4	59.1
338	98	92	73	52	37	23	16	8	3	4	59	37	2.81	42.1	2.4	179	281	227	339	918	2180	1239	2598	53.3	84.1

[a] Proportion of mortar mixture by weight 1 : 2.

TABLE 8.—*Granulometric composition and tensile and compressive strengths of Philippine sands*—Continued.

Tracing No.	Granulometric analysis. Per cent particles passing through screen.									Three-screen analysis. Per cent particles.			Specific gravity.	Percentage of voids.	Uniformity coefficient.	Tensile strength in pounds per square inch (1:3 mortar).				Compressive strength in pounds per square inch (1:3 mortar).				Strength at the age of 28 days. $\frac{\text{Specimen}}{\text{standard}} \times 100$.	
																Sand specimens.		Standard sand.		Sand specimens.		Standard sand.			
	10	20	30	40	50	60	80	100	200	Coarse.	Medium.	Fine.				7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	Tensile.	Compressive.
339	98	76	38	7	3	1	----	----	----	8	89	3	2.51	44.2	1.8	147	242	255	390	868	1621	1756	2688	62.1	60.4
340	87	60	31	16	10	4	3	2	----	26	64	10	2.68	43.3	2.5	192	307	277	393	1358	2472	1700	2578	78.2	96.2
341	97	85	54	28	17	7	4	3	1	6	77	17	2.84	39.1	2.1	254	323	252	343	1183	2027	1945	2404	94.1	84.2
342	79	58	38	22	15	8	4	3	1	32	53	15	2.51	30.3	3.1	162	247	334	392	1042	2110	1736	2350	63.1	90.1
343	92	75	58	40	24	10	7	4	1	17	59	24	2.67	40.1	2.2	111	195	247	417	1026	2084	1590	3367	79.0	61.8
344	98	84	55	28	14	7	4	3	2	10	76	14	2.59	44.4	2.1	112	171	236	366	1014	1541	1758	3200	46.8	48.2
345	88	78	67	42	23	13	7	4	2	22	55	23	2.67	41.2	2.5	173	283	259	344	1480	2454	1707	3176	82.3	77.3
346	80	53	30	17	8	3	2	1	----	34	58	8	2.70	40.1	2.7	243	347	260	369	1304	2563	1673	2377	94.1	108.8
347	81	57	38	26	17	9	4	3	2	33	50	17	2.78	39.5	3.5	200	308	247	342	1163	2346	1663	2568	90.1	91.5
348	96	67	43	27	16	10	6	4	2	18	66	16	2.80	47.7	3.1	188	311	263	365	971	1928	1570	2590	85.2	74.4
349	98	96	83	65	21	11	6	3	----	2	77	21	2.63	41.7	1.6	150	229	259	363	598	894	1116	1956	62.3	45.7
350	98	86	51	34	13	7	4	2	----	2	85	13	2.69	40.5	2.2	217	299	314	386	876	1534	1143	2078	77.5	74.1
351	99	85	54	27	14	8	3	2	----	7	79	14	2.86	44.5	----	271	346	295	343	974	2135	1642	2025	101.5	105.2
352	58	27	14	8	5	3	2	2	1	62	33	5	2.71	36.7	3.7	290	382	257	354	2485	2995	1783	2878	108.1	104.2
353	----	86	65	54	28	16	----	2	----	12	60	28	2.62	------	2.2	215	258	276	348	------	------	------	------	74.2	--------
354	----	76	44	32	17	9	----	2	----	15	68	17	2.63	------	2.6	226	263	276	348	------	------	------	------	75.5	--------
355	97	87	72	54	37	15	8	7	3	7	56	37	2.66	38.7	1.7	201	329	283	372	1413	1855	2394	3677	88.4	50.5
356	98	61	25	12	8	4	3	2	----	20	72	8	2.64	40.1	2.1	220	334	246	335	1830	2608	2102	2712	99.7	96.2
357	97	87	70	50	33	20	12	6	2	7	60	33	2.59	38.1	2.2	233	343	261	405	1213	2011	1503	2552	84.8	78.8
358	100	98	93	88	----	50	----	15	----	------	53	47	2.65	42.5	2.8	[f] 208	[f] 277	[f] 319	[f] 376	[f] 1245	[f] 2120	[f] 2440	[f] 3480	73.6	60.9
359	85	64	39	31	20	14	----	2	----	18	62	20	2.59	38.3	3.3	[f] 274	[f] 357	[f] 319	[f] 376	[f] 2140	[f] 3680	------	------	95.1	--------
360	87	69	48	27	17	10	7	4	2	23	60	17	2.66	31.1	2.9	250	338	318	374	955	1392	1652	1947	90.3	71.6
361	58	40	27	12	6	3	2	1	----	60	34	6	2.60	39.1	3.4	174	282	351	392	1671	3148	2283	2732	72.1	115.1

362	91	72	[illegible]	25	14	8	4	2	1	18	68	14	2.70	44.9	2.4	199	281	251	370	1224	2633	1811	2762	75.8	95.3
363	----	99	90	50	20	5	3	1	----	----	80	20	2.58	40.7	1.5	156	247	267	388	583	997	2004	2491	63.7	40.1
364	100	97	54	18	7	4	2	1	----	2	91	7	2.73	40.1	1.6	247	392	269	388	1209	2408	1555	2598	102.1	92.7
[illegible]	92	[illegible]	[illegible]	22	13	6	3	2	----	20	67	13	2.68	41.1	2.5	272	382	276	373	1530	2510	1795	2499	102.5	100.5
[illegible]	76	47	28	17	11	7	4	3	2	43	46	11	2.67	32.4	4.1	203	417	280	375	2196	3685	2005	2323	111.1	158.5
367	96	74	27	4	2	0.5	----	----	----	11	87	2	2.70	36.8	1.7	225	311	255	390	1448	2172	1756	2688	79.7	80.7
[illegible]	73	[illegible]	11	7	5	1	----	----	----	47	48	5	2.65	39.7	2.1	184	273	216	365	1250	3010	1570	2748	77.1	109.1
369	96	78	57	41	28	16	11	7	2	13	59	28	2.75	34.6	2.9	210	298	330	423	1493	[illegible]	1660	2211	70.4	93.1
370	98	[illegible]	25	10	5	3	2	1	1	24	71	5	2.67	39.6	2.5	246	356	228	361	1506	3008	1592	2068	98.8	145.1
371	90	66	34	17	9	4	3	2	----	22	69	9	2.51	40.7	2.3	149	241	251	380	1266	2378	1228	3206	63.5	74.1
372	84	51	28	16	10	7	4	3	2	33	57	10	2.70	39.2	3.1	132	238	241	335	1014	2054	1406	2282	71.1	90.1
373	97	72	46	28	20	10	2	1	----	17	63	20	2.67	33.5	2.6	157	430	263	309	1176	1679	1279	2115	139.1	79.5
374	96	[illegible]	57	38	17	8	3	2	----	12	71	17	2.68	38.2	2.2	[illegible]	403	288	386	1964	2069	2303	2312	105.2	89.5
375	98	84	50	25	8	4	2	----	----	6	86	8	2.83	37.3	1.8	----	----	----	----	----	3773	----	3120	----	121.1
376	84	55	15	8	4	3	2	----	----	36	60	4	2.63	35.9	2.9	----	----	----	----	----	2870	----	2918	----	98.5
377	[illegible]	64	25	12	6	3	2	1	----	27	67	6	2.75	31.9	2.2	290	436	299	380	1700	3127	1593	2679	114.8	111.6
378	99	90	[illegible]	22	7	3	2	1	----	2	91	7	2.72	33.3	1.7	215	274	322	366	1325	1959	1593	2679	75.1	73.2
379	[illegible]	[illegible]	33	18	12	6	3	2	----	22	66	12	2.79	31.9	2.5	255	380	263	309	923	1234	1176	1679	123.1	73.6
380	[illegible]	66	[illegible]	14	7	4	3	2	2	24	69	7	2.62	38.7	2.1	255	375	277	364	1658	2675	1517	2928	103.1	91.5
381	94	67	23	7	3	2	1	1	----	18	79	3	2.55	33.6	1.7	143	184	206	321	590	1406	1382	2590	57.3	54.3
382	97	87	68	47	31	16	9	7	2	7	62	31	2.66	38.1	2.3	201	311	248	401	1542	[illegible]	1795	2745	77.7	95.6

[f] Proportion of mortar mixture by volume 1 : 3.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels.*

[Two test specimens were prepared from each sample of gravel.]

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
1	Albay	Camalig	Cabraran River		Guinobatan-Jovellar Bridge.		119543	Dec. 7, 1914	Vesicular andesite.
2	Do	Daraga	Yawa River		Albay High School		149636	Jan. 4, 1924	Andesite.
3	Do	Oas	Quinali River		Oas School building		157381	June 9, 1925	Diorite, andesite, and basalt.
4	Do	Polangui	Polangui River		Boraguit Bridge		145625	Feb. 3, 1923	Basalt.
5	Antique	Sibalom	Tipuluan River	A	Sibalom-San José irrigation project.	1.00	151651	May 16, 1924	Basalt and andesite.
6	Bataan	Balanga	Talisay River		Balanga Elementary School.		158268	July 31, 1925	Andesite and diorite.
7	Do	Orani	Orani River		Orani market		144545	Nov. 11, 1922	Diorite.
8	Do	Orion	Pamdan River		Areilano Memorial School.		147805	June 16, 1923	
9	Do	Sisiman	Sisiman quarry	A	Cañacao U. S. Naval Hospital.		158945	Sept. 15, 1925	Andesite.
10	Benguet	Baguio	Government Center		Baguio public works projects.		150865	Mar. 26, 1924	Silicious.
11	Do	do	Engineers hill		do		150865	do	Silicious cherty.
12	Do	do	City quarry		do		150865	do	Limestone.
13	Bohol	Calape	Creek, barrio Sojoton		Calape water reservoir		157989	July 16, 1925	Diorite and limestone.
14	Do	Dauis	Dauis field		Dauis Bridge		146941	May 19, 1923	Limestone.
15	Do	do	Punta Cruz beach, Maribohoc.		do		148043	Aug. 18, 1923	Hard limestone.

16	Do.	Jetafe	Brook, barrio Salog		Jetafe municipal building.		152175	Jan. 23, 1925	Weathered basalt.
17	Do.	do.	do.		do.		152176	do.	Do.
18	Do.	Loay	Beach, kilometer 25		Loboc water reservoir		157256	May 28, 1925	Coralline.
19	Do.	do.	do.		do.		157256	do.	Do.
20	Do.	Maribahoc	Punta Cruz beach, kilometers 14–22.		Provincial Trade School.		155541	Feb. 21, 1924	Do.
21	Do.	Valencia	Seashore at Valencia.		Barrio school		149876	Jan. 14, 1924	Limestone gravel.
22	Bulacan	Angat	Angat River	U	Angat River dam		142812	June 3, 1922	Andesite.
23	Do.	Baliuag	Angat River at Baliuag.	U	Angat River irrigation project.		110912	Dec. 26, 1912	
24	Do.	Bocaue	Bocaue River	U	Pulilan market		121142A	Oct. 12, 1915	Altered basalt.
25	Do.	do.	do.	U	Legislative Building, Manila.		145640A	Feb. 5, 1923	Angular andesite.
26	Do.	do.	do.	U	do.		145640B	do.	Do.
27	Do.	do.	do.	U	do.		145640C	do.	Do.
28	Do.	do.	do.	U	do.		145640D	do.	Do.
29	Do.	do.	do.	U	Angat canal structures		147909	Aug. 2, 1923	
30	Do.	Bustos	Angat River	U	Angat River irrigation project.		142997	June 21, 1922	
31	Do.	Hagonoy		U	Hagonoy market		110032	Nov. 23, 1912	Slightly weathered andesite.
32	Do.	Malolos		U	Malolos Trade School		62645	Nov. 25, 1908	
33	Do.	do.	Pulilan River	U	Malolos waterworks		144590	Nov. 15, 1922	
34	Do.	Pulilan	do.	U	Pulilan market		121142B	Oct. 12, 1915	Basalt.
35	Do.	do.	do.	U	Santa Ana School (Pampanga).		149972	Jan. 31, 1924	Basalt and andesite.
36	Do.	San Ildefonso	Ma-asim River		Angat River irrigation works.		110874	Dec. 25, 1912	
37	Do.	Santa Maria	Santa Maria River		Santa Maria River Bridge.		125490	Oct. 13, 1917	Weathered volcanic.
38	Do.	San Miguel	San Miguel River		Bolo River Bridge		113991A	Apr. 23, 1913	
39	Do.	do.	do.		San Miguel Bridge		147909	Aug. 2, 1923	Andesite and quartz.
40	Do.	do.	At Sibul		Bolo River Bridge		113991B	Apr. 23, 1913	

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
41	Cagayan	Aparri	Cagayan River		Aparri shore protection		151294	Apr. 23, 1924	Andesite.
42	Do	do	Magapit hills		do		150665	Mar. 15, 1924	Limestone.
43	Capiz	Capiz	Barrio Tanza quarry		Bainica River Bridge		155602	Feb. 26, 1925	Andesite and basalt.
44	Do	do	Kilometer 9, Capiz–Paintan road.		Capiz Elementary School.		159395	Oct. 14, 1925	Diorite.
45	Cavite	Cavite	Rio Grande		General Trias School		123520	Nov. 15, 1916	Volcanic.
46	Do	General Trias	Malabon River		do		151028	Apr. 5, 1924	Hard basaltic.
47	Do	Imus	Imus River				123446	Nov. 1, 1916	Vesicular basalt.
48	Do	Kawit	do		Aguinaldo School		122313A	Apr. 28, 1916	Basalt and andesite.
49	Do	do	Rio Grande		do		122313B	do	Basalt and volcanic.
50	Do	do	do		Calero River Bridge		123444	Nov. 1, 1926	Weathered volcanic.
51	Do	Noveleta	San Juan River		Kawit-Noveleta road		81888	Sept. 6, 1910	
52	Do	do	Rio Grande		Noveleta-Cavite road		123306	Oct. 6, 1916	Volcanic.
53	Do	do	San Juan River at bridge.		do		125976	Jan. 2, 1918	Weathered scoriaceous basalt.
54	Do	do	Barrio Bacao		do		125976	do	Hard vesicular basalt.
55	Cebu	Barili	Barrio Guibuañgan		Barili School		152600	July 24, 1924	Coralline.
56	Do	Carcar	Open field out of town.		Carcar waterworks		147128	June 2, 1923	Hard limestone.
57	Do	Cebu	Buhisan Creek		Osmeña waterworks	1.50	152215	June 26, 1924	Basalt and silicious limestone.
58	Do	do	do		do		154355	Dec. 4, 1924	Diorite, andesite, and limestone.
59	Do	do	Guadalupe River		Cebu Normal School	2.25	144670	Nov. 20, 1922	Decayed volcanic.
60	Do	do	do		do	2.25	145779	Feb. 17, 1923	Weathered diorite.

61	Do.	do.	Mananga River.				78560A	May 16, 1910	
62	Do.	Danao.	Danao River.				78560B	do.	
[redacted]	Do.	do.	Rock quarry.		Repairs of provincial bridges.		81168A	Sept. 13, 1910	Silicious limestone.
64	Do.	Dumanjug.	River at Dumanjug.		Dumanjug School building.	2.50	144887	Dec. 4, 1922	Rounded limestone.
65	Do.	Santander.	Santander beach.		Santander municipal building.		156036	Mar. 19, 1925	Coralline.
66	Do.	Talisay.	Mananga River.		Repairs of provincial bridges.		81168B	Sept. 13, 1910	Basalt and andesite.
67	Do.	Toledo.	Tajao River.				122395	May 12, 1916	Basalt and corals.
68	Ilocos Norte.	Laoag.	Laoag River.		Laoag Normal School.		149320	Dec. 6, 1923	Basalt and andesite.
69	Do.	do.	do.		Construction of road and bridges.		121023	Sept. 22, 1915	Andesite.
70	Ilocos Sur.	Candon.	Santa Cruz River.		Candon School building		k151979	June 10, 1924	Do.
71	Do.	Vigan.	Govantes River.		Provincial Hospital.		151330	Apr. 25, 1924	Andesite and diorite.
72	Do.	do.	Mestizo River.		do.		151330	do.	Do.
73	Iloilo.	Oton.			Iloilo Provincial Prison.		88922A	June 14, 1911	
74	Do.	Santa Barbara.	Santa Barbara River.		do.		88922B	do.	
75	Do.	do.	do.		Balucuan-Libas Bridge (Capiz).		121659	Dec. 29, 1915	Basalt and quartz.
76	Do.	do.	Tigum River.		Santa Barbara irrigation project.		137630	Feb. 17, 1921	Diorite and limestone.
77	Do.	do.	Santa Barbara River.		Iloilo Normal School.		154416	Dec. 8, 1924	Basalt andesite and trachyte.
78	Do.	do.	Santa Barbara Pit.		Bainica River Bridge.		155601	Feb. 25, 1924	Basalt and andesite.
79	Do.	San Miguel.	Aganao River.		Aganao River irrigation project.		142720	May 25, 1922	Sandstone, andesite, and quartz.
80	Do.	do.	do.		do.		144036	Oct. 3, 1922	
81	Do.	do.	Oton beach.		do.		145778	Feb. 17, 1923	Andesite and diorite.
82	Laguna.	Los Baños.	Quarry, lower ledge.		Military barracks.		83395A	Oct. 17, 1910	Basalt.
83	Do.	do.	Quarry, upper ledge.		do.		83395B	do.	Do.
84	Do.	do.	Quarry, lower ledge.		do.		83395C	do.	Do.
85	Do.	Majayjay.	Majayjay River.		Majayjay waterworks.		132070	Dec. 6, 1919	Andesite and trachyte.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
86	Do	do	Majayjay rock quarry.		do		132071	do	Worn andesite.
87	Do	do	Olla River stone		Majayjay market		158670	Aug. 27, 1925	Andesite and diorite phorphyry.
88	Do	Pagsanjan	Pagsanjan River, hand picked.		Pagsanjan waterworks		128904	Dec. 6, 1918	Vesicular basalt and andesite.
89	Do	Rizal	Paac River		Rizal School		145191	Dec. 27, 1922	Basalt.
90	Do	Santa Cruz	Santa Cruz River		Santa Cruz Hospital		149828	Jan. 21, 1924	Andesite.
91	Leyte	Barugo	Baluguhay River		Barugo School		121025	Sept. 22, 1915	Diorite, slightly weathered.
92	Do	Carigara	Punong River		Carigara School		145325	Jan. 8, 1923	Weathered diorite and andesite.
93	Do	Ormoc	Anilao River		Ormoc market		159885	Nov. 11, 1925	Diorite.
94	Do	Tacloban	Tigbao River		Tacloban wharf		145557	Jan. 26, 1923	Andesite, highly weathered.
95	Do	do	Punta Anibong		do		150160	Feb. 12, 1924	Diorite.
96	Marinduque	Boac	River bed at Boac		Boac pier	3.00	155970	Mar. 17, 1925	Andesite and basalt.
97	Do	Gasan	Gasan seashore		Matandang Asan Bridge.		151127	Apr. 11, 1924	Andesite.
98	Masbate	Masbate	Togbo River		Masbate market building.		152784	Aug. 7, 1924	Andesite and basalt.
99	Mindanao	Cagayan (Misamis).	Cagayan River		Cagayan wharf		122044A	Mar. 10, 1916	Basalt and andesite.
100	Do	do	Cagayan beach		do		122044B	do	Do.

101	Do.	do.	Cagayan River		Cagayan Central School.		123102	Aug. 24, 1916	Volcanic scoria.
102	Do.	Cotabato (Cotabato).	Limapatoy River		Cotabato Hospital		121500	Nov. 30, 1915	Porous coralline.
103	Do.	do	Rio Grande		do		147912	Aug. 2, 1923	Limestone.
104	Do.	Davao (Davao)	Davao River		Davao wharf		157984	Aug. 20, 1925	Basalt andesite.
105	Do.	do.	do.		do.		157984	do.	Do.
106	Do.	Jolo (Sulu)			Jolo public works		118287	Feb. 21, 1914	Coralline.
107	Do.	do.	Zamboanga River		Jolo wharf	15.00	147514	July 2, 1923	Hard andesite.
108	Do.	do.	Crushed rock from ledge.		do.		154787	Jan. 6, 1925	Gneiss, basalt, and vesicular lava.
109	Do.	Surigao (Surigao).	Beach, Bilar point		High School building		152657	July 29, 1924	Andesite and diorite.
110	Do.	Zamboanga	Baliwasan beach		Zamboanga wharf		156544	Apr. 16, 1925	Vesicular basalt and some limestone.
111	Do.	do.	do.		do.		156544	do.	Do.
112	Do.	do.	do.		do.		156545	do.	Andesite, basalt, and corals.
113	Do.	do.	do.		do.		156545	do.	Do.
114	Nueva Ecija	Cabanatuan	Rio Grande		Provincial Hospital	2.50	150668	Mar. 15, 1924	
115	Do.	Caranglan	River at Caranglan		Kabolipanan Bridge		147349	June 19, 1923	
116	Occidental Negros.	Bacolod	Lupit River		Provincial Hospital		156702	Apr. 27, 1925	Andesite, basalt, and diorite.
117	Do.	Bago	Bago River		Bago School		151985	June 10, 1924	Andesite and diorite.
118	Do.	Cadiz	Talabaan River		Cadiz municipal market.	3.00	158884	Sept. 10, 1925	Andesite.
119	Do.	La Castellana	Bungahin River		La Castellana municipal building.		158982	Sept. 17, 1925	Andesite and diorite.
120	Do.	Maao (Bago)	Maragandang River		Maao School		150747	Mar. 19, 1924	Andesite.
121	Do.	Pulupandan	Bago River		Pulupandan wharf		158272	July 31, 1925	Andesite, basalt, and diorite.
122	Do.	Talisay	Matabang River		Talisay School		151003	Apr. 3, 1924	Diorite.
123	Do.	Isabela	Binalbagan River		Isabela School		153664	Oct. 16, 1924	Andesite and diorite.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter at the job site	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
124	Oriental Negros.	Amblan	Amblan River		Bureau of Public Works project H. H. 44.		79103	June 18, 1910	
125	Do.	Bais	Bais River		Bais River Bridge		122047A	Mar. 10, 1916	Weathered basalt.
126	Do.	do.	do.		do.		122047B	do.	Do.
127	Do.	Dumaguete	Bainica River		Storage tank		145641	Feb. 5, 1923	Vesicular basalt and hard gabbro.
128	Do.	Tanhay	Tanhay River		Bureau of Public Works H. H. 44.		79103	June 18, 1910	
129	Palawan	Coron	Banga River		Coron wharf		155108	Jan. 23, 1925	Ferruginous chert and weathered feldspar.
130	Do.	do.	Coron beach		do.		124027	Feb. 8, 1917	Iron-stained quartz.
131	Pampanga	Angeles	Abacan River		Angeles Bridge No. 89.		146672	Apr. 25, 1923	Diorite.
132	Do.	do.	do.		Angeles Bridge		147418	June 22, 1923	
133	Do.	Magalang	Paitan River		Magalang municipal building.		146670	Apr. 25, 1923	Scoriaceous basalt.
134	Rizal	Binangonan	Angono River		Angono Bridge		121842	Feb. 3, 1916	Basalt.
135	Do.	do.	Talim Island quarry		Pasay concrete road		149665	Jan. 8, 1924	Do.
136	Do.	do.	do.		do.		149776	Jan. 17, 1924	Basalt.
137	Do.	do.	do.		Legislative building		152782	Aug. 17, 1924	Do.
138	Do.	Malabon	Tinajero River				150919	Mar. 29, 1924	Basalt and andesite.
139	Do.	do.	do.	A	Legislative building		152146A	June 20, 1924	Andesite and basalt.
140	Do.		Talim Island quarry.	A	do.		152146B	do.	Basalt.
141	Do.	McKinley	Pasig River	A	do.		152146C	do.	Andesite and basalt.
142	Do.	do.	do.	A	do.		151599	May 14, 1924	Andesite and quartz.

143	Do.	do.	do.		Jones Bridge subway		151983	June 10, 1924	Andesite and a few shells.
144	Do.	Pasig	Pasig River (Talampas).		University of the Philippines engineering laboratory.		147904	Aug. 2, 1923	Slightly weathered basalt.
145	Do.	do.	do.		University of the Philippines chemical laboratory.		149465	Dec. 18, 1923	Basalt and andesite.
146	Do.	do.	do.	A	University of the Philippines High School.		149997	Feb. 1, 1924	Basalt.
147	Do.	do.	Pasig River (Bambang).	A	Jones Bridge		152274	June 23, 1924	Andesite and basalt.
148	Do.	San Juan	Pasig River (Santolan).		Legislative building		154013A	Nov. 11, 1924	Andesite and basalt.
149	Do.	do.	do.		do.		154013B	do.	Weathered diorite.
150	Do.	do.	do.		Philippine General Hospital.		154014	do.	Dark brown diorite.
151	Samar	Borongan	Maylibas River		Borongan Bridge	3.00	150107A	Feb. 8, 1924	Andesite.
152	Do.	do.	do.		do.	3.00	150107B	do.	Do.
153	Do.	do.	Sunco beach		Borongan public buildings.		151147A	Apr. 12, 1924	Do.
154	Do.	do.	Bato River at Canabong.		do.		151147B	do.	Do.
155	Do.	Calbayog	Malopalo, Tinanbacan.		Calbayog municipal building.	4.50	154084	Nov. 14, 1924	Andesite porphyry.
156	Do.	do.	Marcatubig, Tinanbacan.		do.	4.50	154084	do.	Diorite.
157	Do.	Catarman	River at Catarman		Catarman market		151087	Apr. 9, 1924	Slightly weathered andesite.
158	Do.	Llorente	Llorente beach		Llorente School Building.	0.90	152723	Aug. 4, 1924	Andesite.
159	Do.	do.	Llorente River (Payaan).		do.	2.00	152724	do.	Do.
160	Do.	do.	Llorente River (Agus)	A	do.	2.00	152725	do.	Do.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Province.	Municipality.	Location of deposit.	Estimated quantity available. A, abundant; U, unlimited.	For use in the construction of—	Estimated cost per cubic meter at the job site.	Laboratory No.	Date sample was received.	Mineralogic classification.
						Pesos.			
161	Sorsogon	Bulan	San Ramon River		Bulan market		160424	Dec. 28, 1925	Slightly weathered andesite and basalt.
162	Do	Castilla	Kumadkad River	U	Kumadkad Bridge		159121	Sept. 25, 1925	Andesite.
163	Do	Donsol	Donsol River		Market building		14,546	July 5, 1923	Do.
164	Do	Gubat	Sagorong River	U	Sagorong River Bridge	2.50	150245	Feb. 16, 1924	Hard andesite.
165	Do	Juban	Juban River	U	Juban School building	2.50	150555	Mar. 7, 1924	Do.
166	Tarlac	San Miguel	Cutcut River		O'Donnell irrigation project.		158313	Aug. 4, 1925	Quartz, diorite.
167	Do	do	O'Donnell River		do		160176	Dec. 3, 1925	Diorite.
168	Tayabas	Candelaria	Cuyapo River		Candelaria waterworks		156805	May 4, 1925	Andesite and basalt.
169	Do	Lucena	Dumacaa River		Hospital building		149687	Jan. 10, 1924	Do.
170	Do	Tayabas	Alitao River		Tayabas market		152467	July 14, 1924	Basalt diorite.
171	Do	Tiaong	Gugulman River		Tiaong waterworks		156806	May 4, 1925	Andesite and basalt.
172	Zambales	Alhambra	At source of Uacon River.		Lucapon Bridge		128121	Aug. 28, 1916	Volcanic.
173	Do	Cabañgan	Cabañgan River		Iba-Subic Road Bridge		121639	Nov. 28, 1915	Metamorphic.
174	Do	Candelaria	Gala-gala beach		Candelaria School building.		123120	Aug. 28, 1916	Volcanic.
175	Do	do	Lauis River	U	Gamot River Bridge	3.33	122529	June 5, 1916	Do.
176	Do	Santa Cruz	Bayto River	U	Santa Cruz School building.	4.00	146668	Apr. 25, 1923	Hard andesite.
177	Do	do	Perpetuo River	U	do	2.50	145828	Feb. 21, 1923	Weathered basalt.
178	Do	San Marcelino	Santo Tomas River at Santa Fé.		Santo Tomas irrigation project.		153275	Sept. 15, 1924	Andesite.

Tracing No.	Mechanical analysis. Per cent passing through screens (circular openings). 3.00″	2.25″	1.50″	1.00″	0.67″	0.45″	0.30″	0.20″	0.15″	Specific gravity.	Percentage of voids.	Sand used with gravel or stone. Laboratory No.	Compressive strength in pounds per square inch at the age of 28 days. Initial crack.		Ultimate.		Mode of failure. M., mortar. M. G., mortar-gravel. M. S., mortar-stone.
1	100	83	66	46	23	6	1	0.4		2.25	27.1	119543		1977		2210	
2		100	81	42	12	2						149637	2502	2455	3290	3430	M. G.
3		100	98	73	39	10	2.3	0.35	0.3			157382	2082	2282	2547	2451	M. G.
4		100	32		8		0.7					145626		1900		2539	
5	100	98	51	12	1							151652	1231	1171	1607	1539	M.
6		100	75	39	9.8	0.7						158269	3914	2686	4234	4250	M. G.
7												144546	1010	1095	1888	1882	M.
8												147304	[a] 1112	[b] 1187	[a] 1952	[b] 1636	M. G.
9										2.67		([c])	1954	2050	2673	2729	M. S.
10		100	99	41	9	3	1					150866B	686	754	1069	1119	M.
11			100	86	48	17	6					150866A	1640	1694	2122	2099	M. G.
12			100	98	68	25	13					do.	1780	1916	2226	2275	M. G.
13		100	91	18	0.5							157988			1060	1108	M.
14	100	98	26	0.3								146940	1846	1433	2400	2356	
15	100	96	53	7	0.2							146940	1002	1034	1372	1532	M. G.
16		100	92	71	31	7	6	5	4			152172A	1620	1560	1680	1678	M.
17		100	92	71	31	7	6	5	4			152172B	1800	1838	2116	2243	M. G.
18		100	85	13	1.3	0.3						157257A	1954	2319	2988	3176	M. G.
19		100	85	13	1.3	0.3	6	5	4			157257B	1353	1532	1518	1569	M. G.
20		100	91	49	6	0.6						155542	2478	2243	2829	2685	M. G.
21		100	78	14	8							149877	1011	1057	1404	1392	M.
22		100	81	12	0.5							142811	1074	1010	2434	2673	M.
23												110874	2055		2282		
24		100	77	50	30	26	0.4			2.62	38.1	121142A	2017	2506	2017	2506	

[a] Sand No. 147304B. [b] Sand No. 147304C. [c] Ottawa sand.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Mechanical analysis. Per cent passing through screens (circular openings).									Specific gravity.	Percentage of voids.	Sand used with gravel or stone. Laboratory No.	Compressive strength in pounds per square inch at the age of 28 days.				Mode of failure. M., mortar. M. G., mortar-gravel. M. S., mortar-stone.
	3.00″	2.25″	1.50″	1.00″	0.67″	0.45″	0.30″	0.20″	0.15″				Initial crack.		Ultimate.		
25	--------	--------	100	99	87	57	39	24	16	--------	--------	145643	859	--------	1774	--------	M. G.
26	--------	100	99	78	46	18	6	1	--------	--------	--------	145643	820	--------	1650	--------	M. G.
27	--------	100	89	60	30	7	2	0.4	0.2	--------	--------	145643	868	--------	1885	--------	M. G.
28	--------	100	96	83	62	30	17	8	5	--------	--------	145643	1004	--------	1798	--------	M. G.
29	--------	100	97	90	82	62	45	22	--------	--------	--------	149420	1260	1160	1645	1670	M.
30	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	142996	1445	1466	2120	2195	M.
31	--------	--------	100	83	65	41	25	12	7	2.45	29.1	110032	([d])	([d])	([d])	([d])	([d])
32	--------	--------	--------	100	81	--------	--------	40	--------	2.71	35.5	62645	--------	--------	1180	--------	--------
33	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	144591	1022	998	1227	1236	M.
34	--------	100	83	40	18	0.2	--------	--------	--------	2.70	32.3	121142C	2246	2929	2429	2929	--------
35	--------	--------	100	99	95	79	57	--------	--------	--------	--------	[e] 149486	1112	1280	1280	1676	M.
36	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	110874	1986	1820	2102	1976	--------
37	--------	100	83	53	27	5	0.5	--------	--------	2.64	53.2	125491	1460	1222	1460	1222	M.
38	--------	--------	100	96	89	67	43	2	1	2.42	35.1	113991	1472	1680	1594	1720	--------
39	--------	100	97	66	31	6	0.4	--------	--------	--------	--------	147908	1784	1760	2337	2541	--------
40	--------	--------	100	71	57	37	22	11	10	2.45	38.4	113991	1611	--------	1699	--------	--------
41	--------	100	76	35	16	14	11	2	--------	--------	--------	151295	[f] 903	[f] 916	[f] 1007	[f] 1113	M.
42	--------	100	93	21	3	1	--------	--------	--------	--------	--------	150666	991	1023	1146	1229	--------
43	--------	100	87	29	5.5	0.1	--------	--------	--------	--------	--------	[g] 155603	2150	2158	2527	2578	M. S.
44	100	98	76	15	2	0.5	0.1	--------	--------	--------	--------	[g] 159394	2558	2528	3248	3291	M. S.
45	100	99	64	51	40	24	11	2	1	2.44	35.4	123521	[h] 785	--------	[h] 1037	--------	--------
46	--------	100	90	48	12	1	--------	--------	--------	--------	--------	151029	1389	--------	1531	--------	M.
47	--------	100	73	70	62	51	42	25	3	2.10	45.9	123445	[h] 785	--------	[h] 1038	--------	--------
48	--------	--------	100	90	78	63	46	27	8	2.35	37.3	[i] 122314A	881	--------	1588	--------	--------

49			100	87	70	46	34	22	12	2.40	25.4	[j] 122314B	1134		2913		
50	100	74	67	53	44	30	19	9	6	2.60	39.1	123443	1875	[h] 1664	2709	[h] 2020	
51			100	90	77	51	27	13	8	2.39	33.4	([l])	[m] 1651		[m] 1667		
52			100	91	78	56	38	16	9	2.27	34.3	([n])	930		940		
53		100	97	83	66	37	15	2		2.37	38.1	125977			807	795	M.
54	[f] 100	97	91	67	45	23	12	1		2.35	45.1	125977			1135	1098	M.
55		100	63	2								152599	1755	1668	1898	1784	M. S.
56												147129	1133	1490	2740	2560	
57		100	43	1.5	0.5	0.4						152214	1488	1843	1602	1459	M. G.
58		100	69	17	2.7	0.5	0.2					([l])	2088	2151	2278	2318	M. S.
59	100	98	90	67	44	18	5	1				144671	1168	765	1589	1558	M. G.
60		100	79	23	3	0.1						145880	791		1485		M. G.
61												78560	1448	1494	1757	1874	
62												78560	899	901	1385	1474	
63										2.69	46.9	([l])	2597	1639	3104	3183	M. G.
64		100	89	9	2							144888	1207	1036	1665	1584	M.
65	100	96	67	22	6	0.5						156037	1933	1949	2193	2149	M. G.
66										2.70	45.2	([l])	2341	2042	2687	2797	M. G.
67	100	65	59	27	1					2.70	41.5	([l])	2441		2961		M.
68		100	99	91	67	29	9	2				149318	1650	1315	1837	1827	
69		100	92	83	65	18	9	1		2.64	35.6	121023	1527	1171	2281	1943	
70		100	94	54	22	8	1					151978	1292	1203	1423	1535	M.
71										2.67	27.9	151331A	1020	1068	1120	1200	M.
72										2.65	26.1	151331B	1034	996	1180	1157	M.
73													2278		2352		M. G.
74												88922	2667		2715		M. G.
75	100	78	67	43	28	17	8	2	1	2.61	35.2	([l])	[h] 2427		[h] 2578		
76	100	85	79	68	54	32	16	4	2	2.60	28.9		[h] 1244	[h] 1156	[h] 2464	[h] 2347	M. G.
77		100	96	87	67	44	28	13	6			154417	1437	1385	1511	1460	M.

[d] No tests on strengths.
[e] Sand from Pampanga.
[f] Proportion of concrete mixture 1: 2.5: 5.
[g] Sand from Iloilo.
[h] Proportion of concrete mixture 1 : 1.5 : 3.
[i] Sand from Imus River.
[j] Sand from Rio Grande.
[k] Washed and screened.
[l] Pasig River.
[m] Proportion of concrete mixture 1 : 2 : 5.
[n] Rio Grande.
[o] Proportion of concrete mixture 1 : 2 : 4.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Mechanical analysis. Per cent passing through screens (circular openings).									Specific gravity.	Percentage of voids.	Sand used with gravel or stone. Laboratory No.	Compressive strength in pounds per square inch at the age of 28 days.				Mode of failure. M., mortar. M. G., mortar-gravel. M. S., mortar-stone.
	3.00″	2.25″	1.50″	1.00″	0.67″	0.45″	0.30″	0.20″	0.15″				Initial crack.		Ultimate.		
78		100	80	32	11	1.3	0.1					155603	2183	2151	2558	2411	M. G.
79		100	89	65	48	27	16	8	5	2.56		142721	[o] 1000	[r] 830	[o] 1665	[r] 1296	
80		100	96	84	68	40	22	10	5			144037	1456		1977		
81		100	85	62	44	17	5	0.2				145780	856		1531		M.
82			100	22	6	2	0.3			2.58	44.6	86085A	1328	1611	2078	1945	M.
83			100	16	2	0.1				2.58	44.5	86085C		1347		1528	M. G.
84			100	16	2	0.1				2.58	44.5	86085B	1450	1000	1728	1647	M.
85		100	94	70	46	23	14	8	4	2.41	35.8	132068	1566	1701	1863	2002	M. G.
86	100	88	38	4	2					2.37	46.2	132068	2045	2012	2636	2778	M. G.
87	100	98	44	3								158671	2222	2347	3098	3245	M. S.
88										2.28	28.1	128903	1636	1555	2290	2170	
89			100	67	32	1						145733	1591		3260		M. G.
90			88	50	26	8	2	1				149829	2155	2311	3098	3027	M. G.
91	100	88	59	42	14	0.2				2.31	30.6	121025	[o] 1387	[m] 1925	[o] 1895	[m] 2155	M. G.
92		100	94	14	0.5	0.1				2.42		145326	350	275	1416	1673	M. G.
93		100	64	17	3.5	0.2				2.40	48.7	159886	1808	1751	2449	2443	M. G.
94		100	97	90	75	43	29	15	6			121583	1125		1223		M. G.
95	100	83	33	5	1							150161A	1215	1120	1634	1584	M. G.
96		100	92	66	42	19	5.6	0.15	0.05			155971	1629	1634	1744	1771	M. G.
97			100	89	46	8	1					151128	[q] 1327	[r] 541	[q] 1612	[r] 680	M.
98	100	97	62	27	9	1	0.2					152783	1560	1690	2065	2181	M. G.
99			100	98	88	62	40	18	12	2.61	35.4						
100				100	33	3	0			2.62	41.1						

[r] Proportion of concrete mixture 1 : 2.5 : 5.

[o] Proportion of concrete mixture 1 : 2 : 5.

101	-	100	83	34	20	-	-	-	-	2.70	39.6	123101	[s]385	[s]354	[s]558	[s]537	M.
102	-	-	-	-	-	-	-	-	-	2.37	45.1	121499	3024	2686	3024	2686	M. G.
103	-	100	90	56	20	2	0.3	-	-	-	-	147911	1445	1163	2320	2188	-
104	-	100	68	24	6.7	11	0.3	-	-	-	-	157985	2189	2011	3085	2948	M. G.
105	-	100	68	24	6.7	11	0.3	-	-	-	-	157986	1742	1600	2374	1960	M. G.
106	-	-	100	96	85	49	19	15	10	2.39	56.3	118287	982	-	1217	-	M.
107	100	88	26	10	-	-	-	-	-	-	-	147515	1227	1218	2244	2433	-
108	100	99	64	9	-	-	-	-	-	-	-	154786	2733	2628	3844	3680	M. S.
109	-	100	96	66	35	9	2	0.1	-	-	-	152656	1755	1716	1970	1894	M. G.
110	-	100	78	8	2	0.3	0.1	-	-	-	-	156546A	2373	2658	3482	3233	M.
111	-	100	78	8	2	0.3	0.1	-	-	-	-	156546B	2459	2256	3019	3053	M.
112	-	100	89	48	22	5.6	1.7	0.5	0.15	-	-	156546A	3019	2904	3257	3083	M. G.
113	-	100	89	48	22	5.6	1.7	0.5	0.15	-	-	156546B	2556	2667	3194	3201	M. G.
114	-	100	96	81	49	12	1	-	-	-	-	150669	1186	1711	1952	2186	M.
115	100	97	57	5	0.1	-	-	-	-	-	-	147350	1361	1330	2235	2068	M. G.
116	-	100	81	50	31	8	1	0.4	0.1	-	-	156703	1944	2375	2593	2711	M.
117	-	100	90	19	0.2	-	-	-	-	-	-	151982	1390	1367	1828	1732	M.
118	-	100	69	19	3.7	-	-	-	-	-	-	158885	1564	1699	2198	2220	M.
119	-	100	86	48	17	2.4	0.2	-	-	-	-	158983	1994	2006	2509	2456	M. G.
120	100	98	97	52	31	11	2	-	-	-	-	150748	1355	1389	1732	1710	M.
121	100	87	47	53	0.7	-	-	-	-	-	-	158271	2744	2618	4150	3769	M. G.
122	-	100	78	21	3	1	-	-	-	-	-	151004	1847	1948	2742	2466	M. G.
123	100	96	67	38	15	1	-	-	-	-	-	153663	1523	1614	1752	1811	M.
124	-	-	-	-	-	-	-	-	-	-	-	([t])	1900	1976	2147	2300	-
125	-	100	76	46	18	3	0.4	-	-	2.34	28.4	122046	-	-	-	-	-
126	-	100	59	48	26	8	2	0.4	-	2.52	33.8	-	1090	1455	2053	1875	M. G.
127	-	100	95	48	10	1	0.5	-	-	-	-	145642	[u]1008	[v]1792	[u]1122	[v]1977	M. G.
128	-	-	-	-	-	-	-	-	-	-	-	([w])	1809	1822	2025	2539	-

[n] Proportion of concrete mixture 1 : 2 : 5.
[o] Proportion of concrete mixture 1 : 2 : 4.
[q] Sand No. 151128B.
[r] Sand No. 151128A.
[s] Cylinders 8 inches by 16 inches, mixture 1 : 2.5 : 5.
[t] Amblan River.
[u] Sand No. 145642A.
[v] Sand No. 145642B.
[w] Tanhay River.
[x] Test pieces, cylinders 8 inches by 16 inches.
[y] Pasig River.

TABLE 9.—*Mechanical analysis and compressive strengths of Philippine gravels*—Continued.

Tracing No.	Mechanical analysis. Per cent passing through screens (circular openings).									Specific gravity.	Percentage of voids.	Sand used with gravel or stone. Laboratory No.	Compressive strength in pounds per square inch at the age of 28 days.				Mode of failure. M., mortar. M. G., mortar-gravel. M. S., mortar-stone.
	3.00″	2.25″	1.50″	1.00″	0.67″	0.45″	0.30″	0.20″	0.15″				Initial crack.		Ultimate.		
129	--------	100	98	49	14	1	--------	--------	--------	--------	--------	155109	1392	1383	1469	1453	M. G.
130	--------	--------	--------	--------	--------	--------	--------	--------	--------	2.66	44.1	124014	1986	--------	2443	--------	M. G.
131	--------	--------	100	54	2	0.1	--------	--------	--------	--------	--------	146673	1082	--------	2430	--------	M. G.
132	--------	100	44	5	0.6	--------	--------	--------	--------	--------	--------	147419	1117	1343	2077	2277	M. G.
133	--------	100	92	64	35	13	3	1	--------	--------	--------	146671	1036	--------	1899	--------	M. G.
134	100	84	82	56	45	29	17	4	0.4	2.73	88.7	121816	x 901	x 1052	x 1356	x 1686	M.
135	100	99	42	29	28	18	9	4	--------	--------	--------	149666	1394	1470	2400	2456	M. S
136	100	94	52	28	28	21	20	20	--------	--------	--------	149777	1861	--------	3250	--------	M. S.
137	--------	100	87	42	11	1	--------	--------	--------	--------	--------	152145	2185	2066	2952	2834	--------
138	--------	100	69	32	19	7	3	--------	--------	--------	--------	(y)	1493	1552	1846	1882	M.
139	100	98	89	62	33	10	4	0.6	0.3	--------	--------	152145	1670	1650	2303	2285	M.a
140	100	55	5	0.7	0.1	--------	--------	--------	--------	--------	--------	152145	1632	1676	2227	2294	M.a
141	--------	100	97	86	64	28	12	3	0.4	--------	--------	152145					
142	--------	100	98	82	52	23	12	3	0.3	--------	--------	151600	† 1598	†† 1170	† 1900	†† 1374	M.
143	--------	100	98	91	65	32	3	--------	--------	--------	--------	151984	1342	1311	1506	1452	M.
144	--------	100	92	76	61	38	22	12	8	--------	--------	(y)	786	773	1260	1241	M.
145	100	99	92	73	46	20	10	4	--------	--------	--------	149466	1288	1260	2295	2422	M. G.
146	--------	100	92	76	47	20	12	8	--------	--------	--------	(y)	1561	1427	1787	1665	M.
147	--------	100	91	75	49	21	14	9	7	--------	--------	152173	1464	1475	1518	1555	M.
148	100	97	91	81	68	44	25	9	--------	--------	--------	154012	1780	1866	1833	1975	M. G.
149	100	94	87	84	42	16	7	8	--------	--------	--------	154012	1814	1696	1919	1786	M. G.
150	--------	100	80	47	15	1	--------	--------	--------	--------	--------	153845	2208	2086	2394	2404	M. G.
151	100	96	66	28	10	2	--------	--------	--------	--------	--------	150108B	1172	1189	1455	1393	M.
152	95	77	61	45	18	2	--------	--------	--------	--------	--------	150108A	1393	1444	1778	1797	M.
153	--------	100	95	85	55	18	2	--------	--------	--------	--------	151148E	1444	1617	1854	1991	M.

154	100	96	51	24	7	1	--------	--------	--------	--------	--------	151148A	1601	1668	1910	1926	M.
155	100	90	55	29	14	5	2	--------	--------	--------	--------	154091	1790	1857	1910	2062	M.
156	100	94	68	25	4	1	--------	--------	--------	--------	--------	154091	1647	1804	1902	1996	M.
157	--------	100	72	28	7	1	--------	--------	--------	--------	--------	151088	1258	1411	1722	1839	M.
158	100	94	78	31	6	1	--------	--------	--------	--------	--------	152715	1722	1947	2057	2141	M.
159	--------	100	76	33	15	4	2	--------	--------	--------	--------	152714	1893	1762	2037	1950	M.
160	--------	100	73	41	27	11	1	--------	--------	--------	--------	152730	1739	1754	1940	1875	M.
161	--------	100	96	53	6.4	0.1	--------	--------	--------	2.50	35.1	160425	1488	1408	1945	1937	M. G.
162	100	55	5	0.8	--------	--------	--------	--------	--------	--------	--------	159122	2936	2848	3801	3615	M. S.
163	--------	100	98	51	6	4	--------	--------	--------	--------	--------	147547	1131	1274	1943	2164	M. G.
164	--------	100	58	7	0.3	0.1	--------	--------	--------	--------	--------	150246	1133	1238	1665	1800	M.
165	--------	100	60	2	--------	--------	--------	--------	--------	--------	--------	150556	1116	1102	1450	1415	M.
166	--------	100	85	25	2	--------	--------	--------	--------	--------	--------	158312	3298	3076	3879	3628	M. G.
167	--------	100	93	48	13	3	0.6	0.1	--------	2.40	33.1	160177	1965	2126	3079	3397	M. G.
168	100	93	35	4.2	--------	--------	--------	--------	--------	--------	--------	156807	1857	1642	2704	2822	M.
169	--------	100	93	78	53	22	7	1	--------	--------	--------	149688	1757	1920	2149	2210	M.
170	--------	100	91	56	24	6	2	0.5	0.3	--------	--------	152450	1526	1625	1915	2011	M.
171	100	84	15	--------	--------	--------	--------	--------	--------	--------	--------	156808	1861	2080	2383	2669	M.
172	100	91	56	55	--------	--------	--------	--------	--------	2.42	37.8	--------	--------	--------	--------	--------	--------
173	--------	100	49	3.0	0.4	--------	--------	--------	--------	2.39	39.5	--------	--------	--------	--------	--------	--------
174	--------	100	94	18	--------	--------	--------	--------	--------	2.91	31.1	--------	--------	--------	--------	--------	--------
175	100	81	63	6	0.3	--------	--------	--------	--------	2.89	30.7	122530	††† 594	††† 532	††† 877	††† 760	M.
176	--------	100	95	8	2	--------	--------	--------	--------	--------	--------	146669	940	--------	1472	--------	M. G.
177	--------	100	93	48	7	0.3	0.1	--------	--------	--------	--------	145824	1059	--------	1720	--------	M. G.
178	--------	100	87	24	1	--------	--------	--------	--------	--------	--------	153274	1650	1790	2257	2523	M.

[y] Pasig River.

[z] Equal volumes of Talim Island crushed stone and Pasig River gravel.

† Sand No. 151600A.

†† Sand No. 151600B.

††† Cylindrical specimen 8 inches by 16 inches.

PHYSICAL CHARACTERS OF THE AGGREGATES AS REPORTED IN TABLES 8 AND 9

ALBAY PROVINCE

The sand specimens from Albay Province are well graded, the coarse and medium particles being well balanced, with a relatively smaller percentage of fine particles. The uniformity coefficient, as well as the specific gravity, is fairly high and indicates the good quality of the sands. They possess good mortar strength, both tensile and compressive.

Few gravel specimens were received from Albay Province; all of them, however, possess good compressive strength, when properly used in concrete with sand from the same locality.

ANTIQUE PROVINCE

There is wide variation in the physical characters of the sands from Antique Province. In general, they are composed of medium-coarse particles; the average specific gravity is fairly high; the uniformity coefficient varies from 1.6 to 6.1. Three samples from Sibalom River are of widely different granulometric composition: No. 151469 is medium-fine sand, No. 151652 is medium sand, and No. 151980 is medium-coarse sand. The first two specimens have low tensile and compressive strengths; the third, however, is very satisfactory. Another poor specimen is that from Timpuluan River, No. 152179B; this is medium sand, has very few coarse particles, and has a low uniformity coefficient. The tensile and compressive strengths of this sand are somewhat low. On the other hand, a coarse sand from Magranca beach (No. 154419), in spite of its low uniformity coefficient (1.8), has shown very high tensile and compressive strengths.

There is only one gravel specimen from Antique Province; it is from Timpuluan River. Its low strength is due to poor grading and to the poor quality of the sand used. Indications are that gravel deposits are found also in the beds of Sibalom River, but they are of inferior quality.

BATAAN PROVINCE

The sands from Bataan Province are composed mainly of medium-coarse particles; they have fairly high specific gravity, and a rather variable uniformity coefficient. In general, they have high tensile and compressive strengths. A medium-fine sand specimen from Mariveles beach, No. 117596, has exceptionally low compressive strength, undoubtedly owing to its high percentage of voids and low uniformity coefficient.

A few gravel specimens were received from Bataan Province. No. 158268, from Talisay River, mixed with the sand from the same locality, has exceptionally high compressive strength; on the other hand, No. 144545, from Orani River, has somewhat low compressive strength, because of the poor quality of the sand used.

BATANGAS PROVINCE

Owing to the volcanic nature of the origin of the sand specimens from Batangas Province, their specific gravity is relatively low; the granulometric composition is fairly variable, but variation in the uniformity coefficients is small. The highest tensile strength registered was 305 pounds and the highest compressive strength was 2,343 pounds per square inch; the average values are very much lower, indicating that the sands from this region are of inferior quality.

Some gravel specimens were received from Batangas Province. The results of the tests, however, were not incorporated in the tables, because reliable data on the location of the deposits were not furnished. Like the sands, they are of inferior quality.

BENGUET SUBPROVINCE

The sand specimens from Benguet Subprovince, with the exception of those from Trinidad, are not natural sands; they are screenings. The medium-coarse natural sand from Trinidad, No. 110110B, showed a tensile strength of 504 pounds against 220 pounds of the medium-fine sand, No. 110110A, from the same place. The coarser stone screenings gave very much higher tensile and compressive strengths than did the finer screenings.

Only crushed stones and no gravel were received from Benguet. The limestone and chert mixed with the screenings from the same rocks gave fairly good compressive strength.

BOHOL PROVINCE

The medium-sized particles predominate in the greater number of the sand specimens from Bohol Province. The specific gravity is fairly high, but the uniformity coefficient is very low. The presence of the medium particles and especially the medium-fine particles in predominating quantities and, to a certain extent, the low uniformity coefficient are no doubt the causes of the low tensile and compressive strengths of the greater number of the Bohol sands. Satisfactory results were obtained with the coarse sands taken from the mouth of Panangatan River, No. 150416B; from Punta Cruz beach, No. 155542; and from

kilometer 25 at Loay, No. 157257A. The medium-coarse sands from the seashores of Tagbilaran, No. 156614, and Umpas, No. 156616, and the medium sands from the seashores of Tanguhay and Duero, Nos. 145398 and 145399, also gave satisfactory results.

Many gravel specimens from Bohol are likewise of low quality; however, the two specimens from Punta Cruz beach, No. 155541, and from kilometer 25 at Loay, No. 157256, showed exceptionally high strength. Some mortar failures should be attributed partly to the poor quality of the sand used and partly to the poor grading of the gravels.

BULACAN PROVINCE

Although the sand specimens from Bulacan Province are mostly composed of medium particles, as a whole they have good tensile and compressive strengths. The specific gravity is fairly high and there is little variation in the uniformity coefficient. Three samples, Nos. 142811, 142996, and 145288C, composed of medium-coarse particles and having a low percentage of voids, are especially mentioned here because of their exceptionally high compressive strength, the three samples showing 4,706, 4,336, and 3,200 pounds per square inch, respectively. These sands were taken from Angat River; the first at Angat, the second at Bustos, and the third at Pulilan. The Bustos sand is well graded, showing a low percentage of voids (21.8), a fairly high uniformity coefficient (3.85), and an exceptionally high tensile strength (518 pounds per square inch), which is far above that of Ottawa sand.

Gravel of good quality from Bulacan Province comes mainly from Angat River. Gravels taken from Bocaue River, with the exception of one, No. 121142B, showed somewhat low compressive strength. However, it is always possible, by mixing this gravel with that from Angat or some other locality in Bulacan Province, to obtain a fairly good concrete material.

CAGAYAN PROVINCE

Few sand specimens were received from Cagayan Province. Unfortunately, none of them has given satisfactory results, no doubt because of the poor granulometric composition of the sand, which is composed mostly of fine particles and medium-fine particles.

Two gravel specimens were received from Cagayan Province, and both showed very low compressive strength.

CAMARINES NORTE PROVINCE

The only sample of sand received from Camarines Norte Province is a medium-coarse quartz sand, possessing a high uniformity coefficient, and exceptionally high tensile and compressive strengths.

No gravel specimen was received from this province.

CAPIZ PROVINCE

The sand specimen from Panay River, No. 121656, and one of the two specimens from the junction of Lauan and Capiz Rivers, No. 121434, have fairly high compressive strength. It is interesting to note the great difference in the compressive strength of the sands from two points of the same river junction, Nos. 121658 and 121434. Their granulometric composition is about the same; both are composed mainly of medium and fine particles; both have practically the same specific gravity; they have the same uniformity coefficient; and there is very slight difference in the percentage of voids. However, the compressive strength of No. 121434 is about 260 per cent of the compressive strength of that of No. 121658. This is possibly due to the quantity of clay, about 5.5 per cent, and a small amount of weathered material contained in No. 121658.

No gravel specimen from Capiz Province was submitted for test. The crushed stones taken from quarries, one located at barrio Tanza, and one at the Capiz-Paintan road, kilometer 9, are of good quality and both possess the strength required for use in concrete construction work.

CAVITE PROVINCE

The sands from Cavite Province, like those from Batangas Province, are characterized by low specific gravity, owing to their volcanic origin. Their granulometric composition is good; they are mainly composed of medium-coarse particles, and a very small proportion of fine particles; the uniformity coefficient is fairly high, but the tensile and compressive strengths are low, with the exception of sample No. 149506, from Noveleta River, which has a compressive strength of 2,220 pounds per square inch.

The gravels, like the sands, are of volcanic origin. With the exception of No. 122313B, from the Rio Grande, the specimens tested are of poor quality for use in concrete work.

CEBU PROVINCE

There is considerable variation in the granulometric composition and uniformity coefficient of the sands from Cebu Province. Most of the specimens are composed of medium-coarse sands, have fairly high compressive strength, and in some cases correspondingly high tensile strength. One sample, from Argao River, No. 147975B, composed almost entirely of coarse screenings, is especially mentioned here, because of its unusually high tensile and compressive strength.

Gravel of good quality is also available in many localities in Cebu. Two samples, one from a limestone quarry at Danao and another from Mananga River, Nos. 81168A and 81168B, mixed with Pasig River sand, showed compressive strengths of 3,183 and 2,797 pounds per square inch, respectively.

ILOCOS NORTE PROVINCE

The few sand specimens from Ilocos Norte Province were taken from Laoag River. They are fairly good, except the specimen taken at the dam site (No. 150853) which, being somewhat weathered, gave low tensile and compressive strengths.

Two gravel specimens were also taken from Laoag River. They possess fairly good strength. Better selection and proper proportioning and grading of the materials will give better results.

ILOCOS SUR PROVINCE

The sands from Ilocos Sur Province are mainly composed of medium-fine particles possessing low uniformity coefficient, and high specific gravity. Indications are that sands of good quality can be secured from Ilocos Sur Province.

The few gravel specimens received from Ilocos Sur Province are of good quality, being mainly composed of hard andesitic fragments. Their low compressive strength is due to the poor quality of the sands used.

ILOILO PROVINCE

The sands from Iloilo Province in general are medium-coarse sands possessing rather variable uniformity coefficient but fairly uniform specific gravity. The tensile and compressive strength at the age of twenty-eight days is also uniformly high, with the exception of the specimen from Jaro River, No. 154417. The Iloilo sands, judged by the results of the test, are quite satisfactory for use on concrete construction work.

The gravels, likewise, possess satisfactory compressive strength, except No. 142720, from Aganao River, which contains 15 per cent clay and silt; No. 145778, from Oton beach, which was tested under special conditions (that is, exposed in the open air for twenty-eight days) ; and No. 154416, from Santa Barbara River, which failed because of the poor quality of the sand.

LAGUNA PROVINCE

The sands from Laguna Province are composed of medium-coarse particles, and the specific gravity, uniformity coefficient, and the tensile and compressive strengths are very variable. The highest two compressive strengths registered were 4,721 and 4,390 pounds per square inch, corresponding to No. 143644, from Mayton River, and No. 149829, from Santa Cruz River, respectively. Incidentally, these two specimens have also the highest specific gravity, 2.70 and 2.77, respectively. With very few exceptions, the Laguna Province sands can be considered of satisfactory quality for use in concrete work.

The gravels also possess high compressive strength, especially those from Santa Cruz and Olla Rivers. The low results shown by a few specimens were due to the poor sands used. The crushed stone from a Los Baños quarry, No. 83395, is of poor quality.

LEYTE PROVINCE

Most of the Leyte sands are composed of medium-fine particles with very little or practically no coarse particles. Although the specific gravity is fairly high, the tensile and compressive strength is unsatisfactory, owing perhaps to the general low uniformity coefficient and the high percentage of voids of the specimens submitted; as a matter of fact, only seven of twenty-two samples, or about 33 per cent, gave satisfactory results.

Few gravel specimens were received from Leyte Province. With the exception of the sample from Baluguhay River, No. 121025, they show low compressive strength.

MARINDUQUE PROVINCE

The sands from Marinduque Province, although of medium-fine particles, have high specific gravity, and a low percentage of voids; it is for this reason that they have fairly good tensile and compressive strengths, except the fine sand from Matandang River.

Only two gravel specimens were received. Both have low compressive strength.

MASBATE PROVINCE

Few sand specimens were received from Masbate Province. Three are medium sand and one is medium-coarse. The specific gravity is fairly high and the uniformity coefficient slightly variable and fairly good, but the tensile and compressive strengths are relatively low.

Only one gravel sample was received from Masbate Province; it was taken from Tagbo River. It has fair compressive strength, in spite of the relatively low strength of the sand with which it was mixed.

MINDANAO ISLAND

In as much as there are only a few well-organized municipalities in Mindanao, the exact locations of the deposits of the aggregates were not clearly stated on the cards attached to the specimens; for this reason, all the aggregates are here considered under one heading.

The sands were gathered mainly from the seashores and only a few from the rivers. In general, they possess good tensile and compressive strengths. Good sands are not localized in any definite section of the island; they are found in Zamboanga, as well as in Sulu, Cotabato, Davao, and Cagayan. The following specimens have given exceptionally high tensile and compressive strengths: No. 123101, from Cagayan River; No. 154786, from Zamboanga beach; Nos. 156546A and 156546B, from Baliwasan beach; and No. 157985, from Davao River. These sands are characterized by low percentage of voids, fair specific gravity, and the presence of a higher proportion of coarse grains.

The gravels, like the sands, have given very satisfactory compressive strength. Many of the specimens have a breaking strength of 3,000 pounds or more per square inch.

NUEVA ECIJA PROVINCE

Two sand specimens were received from Nueva Ecija Province; one, composed of medium-coarse particles, and the other of coarse particles. Both specimens possess good tensile and compressive strengths.

Also, two gravel specimens were received. Both can be considered of fair quality for use in concrete work.

OCCIDENTAL NEGROS PROVINCE

In general, the sand specimens from Occidental Negros Province may be rated as fair. They are composed mostly of medium particles; the specific gravity, on the whole, is below

the average and, although the percentage of voids is relatively lower, the tensile and compressive strengths are not very satisfactory. However, samples No. 148964, from Alejandra River, and No. 159768, from Bungalin River, have given compressive strengths of 3,260 and 3,509 pounds per square inch, respectively.

The gravels, on the other hand, have good compressive strength. The low results registered were due to mortar failures, owing to the poor quality of the sands used.

ORIENTAL NEGROS PROVINCE

Three sand specimens were received from Oriental Negros Province. Like those of Occidental Negros, they are composed of medium particles. Their specific gravity and tensile and compressive strengths are below the average values for good concrete aggregates.

The gravels, however, have fairly good compressive strength.

PALAWAN PROVINCE

The sands from Palawan Province are mainly composed of medium particles; they have a fairly good uniformity coefficient but low specific gravity, due to the weathered condition of the particles. The percentage of voids is high, with the exception of No. 157987, from Coron beach, at the wharf. The tensile and compressive strengths of this specimen were 352 and 2,405 pounds per square inch, respectively.

The gravel specimen from Coron beach is likewise of good quality, but that from Bonga River is very poor.

PAMPANGA PROVINCE

The sand specimens from Pampanga Province are of medium-fine particles and have fair specific gravity and uniformity coefficient, and a comparatively low percentage of voids. The sands, although lacking in coarse particles, are well graded, and consequently possess good compressive strength.

The few gravel specimens submitted from Pampanga Province are of fair quality and, with the exception of No. 146670, from Paitan River, possess the necessary strength required for concrete work.

PANGASINAN PROVINCE

The sands from Pangasinan Province possess the good qualities of high specific gravity and low percentage of voids. They are composed of medium particles and, in general, have a low uniformity coefficient. It is possibly for this reason that the tensile strength is low, although the greater proportion of

the specimens have good compressive strength. Sands No. 144072, from Agno River, and No. 146985, from Aguilar River, have exceptionally high tensile and compressive strengths. Several other specimens have shown higher strength than the standard sand mortars.

No gravel samples were received from Pangasinan Province. Our records on concrete specimens submitted for test, however, indicate that gravels of good quality are found in the beds of many rivers, such as the Abeloleng, the Anonilintap, the Manaog, the San Jacinto, etc.

RIZAL PROVINCE

Perhaps no other sand deposit in the Philippine Islands has been so extensively developed as has that of Pasig River, Rizal Province. Proximity to the City of Manila, where concrete construction work is constantly increasing in volume, is the main cause of this development. Abundant material is available almost any time and prices are reasonable. The materials delivered at the job site cost about 2 pesos and 5 pesos per cubic meter of sand and gravel, respectively.

In general, the sand specimens from Rizal Province are composed of medium-coarse particles; they have fairly good average specific gravity, and a tolerably low percentage of voids. With a few exceptions, the tensile and compressive strengths are very satisfactory; as a matter of fact, in many instances, the Pasig River sand showed higher strength than did standard Ottawa sand.

Pasig River gravel is also of good quality. The low compressive strength registered in the majority of the cases was due to mortar failures. The smooth surface of this gravel, the fact that, oftentimes, it is covered with a film of dirt difficult to remove and, to a certain extent, the poor grading of the materials used in the mixtures are possibly the reasons for the low strength of concrete made from it. In no case has concrete made from this gravel shown the exceptionally high compressive strength that the concrete made from certain specimens from Mindanao and Occidental Negros showed; but, for ordinary purposes, it is a reliable concrete aggregate. Mixtures in the proportion of 1 : 2 : 4 would easily pass the minimum limit of 2,000 pounds per square inch, at the age of twenty-eight days, specified by the Bureau of Public Works.

In this connection, the experience of two practicing engineers of the City of Manila is of interest. In view of the frequent low strength noted in specimens submitted by these engineers for test at the Bureau of Science, they decided to study the cause of the trouble. After several weeks of observation at the site of the work where these materials were being used, they arrived at the conclusion that thorough washing of the materials and conscientious grading of the gravel particles are the necessary requisites to prepare 1 : 2 : 4 concrete cubes that will give a compressive strength of over 2,000 pounds per square inch at the age of twenty-eight days.

To correct the low strength of concrete made of concrete materials from Pasig River, some contractors used, for the coarse aggregate, equal proportions of river gravel and crushed stone from Talim Island. This practice has given very satisfactory results. The gravels taken from Angono, Tinajero, and San Juan Rivers are of similar concrete value as are the Pasig River gravels.

ROMBLON PROVINCE

Few sands were received from Romblon Province; they are of a calcareous nature, either coralline limestone or marble débris. They are medium sands with fairly high specific gravity and rather variable uniformity coefficient. In this particular province, where the specimens are of similar mineralogic classification, those having higher specific gravity, higher uniformity coefficient, and a low percentage of voids also possess higher tensile and compressive strengths.

No gravel or crushed stone specimens were received from Romblon Province. It is safe to assume, however, that crushed marble from marble rocks, which are found in large quantities in this province, will give satisfactory results as concrete aggregates.

SAMAR PROVINCE

The sands from Samar Province are composed mainly of medium-coarse particles, a relatively low percentage of voids, and variable uniformity coefficient and specific gravity. Wide variation is also observed in the tensile and compressive strengths. A coarse-medium sand, No. 119453, from Calbayog beach, has exceptionally high tensile and compressive strengths. This sand has a specific gravity of 2.77. Another medium-

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coarse sand, No. 151148B, from Borongan River, gave the lowest tensile and compressive strengths. The specific gravity of the sand is 2.42. There was plenty of clay in the sample.

The gravels from Samar, with the exception of the two specimens from Maylibas River, gave satisfactory compressive strength. All the failures were mortar failures, indicating sand of poor quality or dirty gravel.

SORSOGON PROVINCE

The sand specimens from Sorsogon Province are mainly composed of medium and medium-coarse particles. The variation in the uniformity coefficient is small, but the variation in the specific gravity is noticeable. Although the compressive strength is fairly satisfactory, the tensile strength is low. Sand samples having the highest specific gravity have registered the highest tensile strength, showing once more the close relationship between density and strength.

The gravels from Sorsogon Province are hard dense rocks of good quality for concrete work. The low compressive strength should be attributed partly to the poor granulometric composition of the specimens and partly to the poor quality of the sands used.

SURIGAO PROVINCE

Two sand samples were received from Surigao Province and both have low tensile and compressive strengths. They are medium sands, of low uniformity coefficient and with a high percentage of voids, but with fairly good specific gravity.

No gravel was received from Surigao.

TARLAC PROVINCE

The Tarlac sands are medium-fine sands, possessing fairly good specific gravity, rather variable uniformity coefficient, and a somewhat high percentage of voids. The tensile and compressive strengths, with few exceptions, are generally good. The low strength of the specimens from O'Donnell River is due mainly to the mineralogic character of the sands. Sand No. 123447, from Santiago River, which registered the highest tensile and compressive strengths,[31] possesses all the good properties of a good mortar sand; namely, coarse particles, high

[31] Highest of the 1:3 mixture.

specific gravity, high uniformity coefficient, and low percentage of voids.

Two gravel specimens were received from Tarlac Province, one from Cutcut River, the other from O'Donnell River; they possess exceptionally high compressive strength.

TAYABAS PROVINCE

The granulometric composition of the sands from Tayabas Province is fairly good. These sands are composed mainly of medium particles, but many of the specimens also contain a good proportion of coarse particles. The average specific gravity is high and the uniformity coefficient somewhat variable. The highest tensile and compressive strengths were registered by a medium coarse sand with a low percentage of voids and a high uniformity coefficient. Some specimens showed good compressive strength but low tensile strength.

Few gravel specimens were received from Tayabas Province. They all possessed good compressive strength without gravel failures.

ZAMBALES PROVINCE

The sands from Zambales Province are composed mainly of medium particles, the uniformity coefficient is fairly low, the average specific gravity good, and the percentage of voids fair. They possess better tensile strength than compressive strength. Sands Nos. 123118 and 123119, from sitio Galagala and Lucapon River, respectively, are especially interesting in this respect. The tensile strengths are 123.1 per cent and 139.1 per cent, respectively, of the corresponding tensile strength of the standard Ottawa sand mortar, while the compressive strengths are lower, 73.6 per cent and 79.5 per cent, respectively, of the corresponding compressive strength of the standard Ottawa sand. Judged from the point of view of their tensile strength, the sands are of a superior grade; but, from the results of compressive-strength tests, they are of poor quality for use in concrete work. The two samples are from volcanic rocks, while the rest are andesitic and quartz.

The gravels, in general, possess low compressive strength. Sample No. 153275, from Santo Tomas River, mixed into concrete with sand from the same locality, gave fairly high compressive strength.

SUMMARY AND CONCLUSIONS

Natural deposits of sand and gravel are found in all the provinces of the Philippine Islands.

Sands consisting mainly of medium and fine particles are the most abundant.

Fewer gravel deposits containing large quantities of the material have been located at easily accessible places.

Good aggregates are found in relatively large proportion in Albay, Bulacan, Cebu, Laguna, and Rizal Provinces and on Mindanao Island.

For a given proportion of cement, the mortar and concrete values of hard-grained aggregates depend, to a considerable extent, upon the granulometric composition of the sand and the mechanical analysis of the gravel.

Coarse sand makes stronger mortar than does fine or medium sand. Coarse sand, mixed with well-graded gravel, makes stronger concrete than does coarse sand mixed with poorly graded gravel.

A gravel specimen that contains stones of a maximum size of 3 inches may be considered well graded when not more than 22 per cent will pass through holes 0.67 inch in diameter, and not less than 22 per cent is retained on a sieve with holes 1.5 inches in diameter. Its apparent ideal mechanical analysis graph is a straight line.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Tensile-strength curves computed on the basis of the tensile strength of standard Ottawa sand as 100 per cent.

2. Compressive-strength curves computed on the basis of the compressive strength of standard Ottawa sand as 100 per cent.

3. Relation between compressive strength and the percentage of coarse, medium, and fine particles, representing the granulometric composition of sands.

4. Average mechanical analysis curves of gravels used in the testing of concrete specimens, grouped according to their compressive strengths as shown in Table 7.

EFFECT OF CARBON TETRACHLORIDE, CHENOPODIUM, AND THYMOL ON THE OVA OF EXPELLED HOOKWORMS

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The object of this study was to find out whether a drug against hookworm exerts any action on the ova contained in the uteri of expelled female worms. If it can be demonstrated that a vermifuge is capable of inhibiting the development of the larvæ or completely killing the ova even when these are kept under favorable conditions, then such ovicidal action not only may indicate the ancylostomicidal power of the drug but also may possibly be used as an index or coefficient of efficiency.

In a series of observations on hookworms removed from patients and cadavers to determine the maturity and fertility of the females, it was observed that those obtained from autopsy when left in clean tap water at room temperature (25 to 30° C.) for twenty-four hours always, on being crushed between slides, showed motile, free-swimming larvæ, or at least moving, coiled larvæ in the shells, provided the ova had been fertilized.

It was observed that, when the number of parasites was large, almost every female had been fertilized. In only rare cases could an immature or unfertilized female be found.

The present observations were made on female hookworms, removed by treatment, from twenty-five patients. The drugs used in this study were carbon tetrachloride in the dose of 1 cubic centimeter to 7 kilograms and 1 cubic centimeter to 5.5 kilograms of body weight, and without any purgative; chenopodium, 3 cubic centimeters given in 1.5-cubic centimeter doses followed by magnesium sulphate; thymol, 2.6 grams given in 1.3-gram doses followed by magnesium sulphate. All observations were on first treatments, on twenty-four-hour stools, collected and screened (80 meshes to the square inch). Usually half the number of worms were crushed the first twenty-four hours and the other half twenty-four hours later.

Table 1 shows that, in seven patients treated with carbon tetrachloride, a total of one hundred fifty-three female worms

did not show development of active larvæ, either free-swimming or motile in the shell. The ova usually showed swelling and fine granulation with filling up of the shell. In some the shell could hardly be distinguished. Fat globules were frequently seen in the ova.

TABLE 1.—*Worms from patients treated with carbon tetrachloride.*

Patient.	Amount of carbon tetrachloride.	*Ancylostoma.*		*Necator.*		Females with larvæ.	Females without larvæ.
		Male.	Female.[a]	Male.	Female.		
	cc.						
1-IC	10	0	2	70	68	0	68
4-MP	10	0	0	2	3	0	3
7-YK	11	0	0	1	4	0	4
8-SM	10	0	0	0	3	0	3
9-MC	7	6	4	9	17	0	17
VA	10.5	1	0	2	5	0	5
DB	6.8	2	1	48	53	0	53
Total					153		153

[a] Not examined.

Table 2 shows that, in ten patients treated with chenopodium, eighty-five female worms showed larval development while three did not, out of eighty-eight worms examined.

TABLE 2. —*Worms from patients treated with chenopodium.*

Patient.	Amount of chenopodium.	*Ancylostoma.*		*Necator.*		Females with larvæ.	Females without larvæ.
		Male.	Female.	Male.	Female.		
	cc.						
JM	3	2	0	17	13	13	0
TR	3	0	0	4	8	8	0
JT	3	0	0	3	3	3	0
FS	3	0	0	18	24	24	0
EA	3	10	1	6	5	6	0
DF	3	0	0	6	7	4	3
IT	3	0	0	0	1	1	0
DB	3	1	0	4	8	8	0
RC	3	1	0	6	12	12	0
SP	3	0	0	7	6	6	0
Total			1		87	85	3

Table 3 shows that, in eight patients treated with thymol, eighty-eight female worms showed active larvæ while eleven did not, out of ninety-nine worms examined.

TABLE 3.—*Worms from patients treated with thymol.*

Patient.	Amount of thymol.	*Ancylostoma.*		*Necator.*		Females with larvæ.	Females without larvæ.
		Male.	Female.[a]	Male.	Female.		
	g.						
JI.	2.6	0	0	3	14	13	1
JE.	2.6	0	0	2	5	1	4
MA.	2.6	1	0	33	35	35	0
P.d.l.R.	2.6	4	3	9	10	9	1
JB.	2.6	0	0	10	14	13	1
MB.	2.6	0	0	13	17	15	2
SV.	2.6	0	0	0	1	1	0
MG.	2.6	0	0	5	3	1	2
Total.					99	88	11

[a] Not examined.

Ten female worms in the patients treated with carbon tetrachloride, three in those treated with chenopodium, and eleven in those treated with thymol were found to be without ova (immature) or with ova but showing no division in them (probably mature but not fertilized).

These findings show that carbon tetrachloride as administered is ovicidal, while chenopodium and thymol are not. The observations were mostly on *Necator*, as *Ancylostoma* were few in this series. The findings also seem to confirm the superiority of carbon tetrachloride over the other drugs in this respect.

It may be mentioned here that fifty-six female worms expelled from three adult patients treated with 2 cubic centimeters of tetrachlorethylene did not show larval development except that two female worms contained motile larvæ. One worm from one patient had a free motile larva at the forty-eighth hour after recovery from the stool and another worm from another patient had a coiled moving larva in the shell, also at the forty-eighth hour after recovery.

Thymol was found many times in small lumps in the stool, though it was in very finely powdered form when put into the capsules. In one case two pieces of thymol of the shape of and practically the same size as the capsules administered were encountered in screening the stool. This finding seems very significant, as the frequent failure of this drug may be due to lump formation. It is possible that this may happen not only in the case of solid drugs but also with carbon tetrachloride, the tendency of which is to form globules of varying

sizes in the dependent portion of the container even when thoroughly emulsified. If this could be shown to occur in the intestinal tract (due to failure of peristaltic movements to keep the drug in finely divided form), then the most rational thing to do would be to prepare the drug in such a way as to keep it well separated or emulsified during its journey through the small intestines.

An inert, porous, powdered solid is suggested as a vehicle for anthelmintics, to be triturated with the drug in case it is solid or mixed in the form of paste in the case of a liquid and put up in capsules. The powdered condition of the vehicle, or "carrier," will mechanically prevent fusion of solid drugs. Owing to porosity it will absorb liquid drugs in minute quantities. Charcoal or chalk will probably serve; both are relatively nonirritating, and they do not predispose the mucosa to absorption.

SUMMARY

1. Twenty-five patients were divided into three groups; those of the first group were given carbon tetrachloride in doses of 1 cubic centimeter to every 5.5 kilograms of body weight and 1 cubic centimeter to every 7 kilograms of body weight; those of the second group were given chenopodium, 3 cubic centimeters in two 1.5-cubic centimeter doses, followed by magnesium sulphate; and those of the third group were given thymol, 2.6 grams in two doses of 1.3 grams each, followed by magnesium sulphate.

All stools for twenty-four hours were saved and screened, and the parasites left in separate Petri dishes with tap water at room temperature (25 to 30° C.). They were crushed between slides, some of them twenty-four hours after recovery of parasites and the others the following twenty-four hours.

2. The female parasites expelled by carbon tetrachloride failed to show development of ova into active larvæ, while those expelled by chenopodium and thymol all showed active larval development, except a few, probably immature or unfertilized ones. Mostly *Necator* were examined, as *Ancylostoma duodenale* were few in this series.

3. This ovicidal property of carbon tetrachloride seems to confirm its superiority over chenopodium and thymol in the treat-

ment of ancylostomiasis. Tetrachlorethylene has also been found to be ovicidal.

4. If the results of this study could be confirmed in a larger number of cases, it might be of value in determining the ancylostomicidal coefficient of a drug.

5. Improper emulsification of a vermifuge in the intestine may be responsible for failure.

6. The use of an inert, porous, powdered solid as a vehicle for anthelmintics is suggested.

NEW OR NOTEWORTHY PHILIPPINE BIRDS, V

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TWO PLATES AND ONE TEXT FIGURE

This paper contains descriptions of two new species of Philippine birds and notes on other species that are of particular interest for one reason or another.[1]

MEGAPODIUS CUMINGI Dillwyn.

In May, 1922, Mr. Luis J. Reyes, of the Philippine Bureau of Forestry, left in my office an egg of the tabon with a note that it had been collected near Agloloma, Luzon, on April 7. As the mound builder is not common in Luzon I asked Mr. Reyes for any notes he might have about this bird. On May 16, he sent me the following notes and description of the nesting habits:

> Agloloma is a sitio of the Municipality of Mariveles, Bataan, located about seven or eight miles northeast of the town.
>
> Tabon birds are not familiar to me, but I was interested in the description of the manner these birds lay their eggs, as told by the man who collected them. He said that a small flock came one day, and after flying around the place for sometime alighted on the sandy beach. The egg was laid on the surface, and after resting one or two minutes the bird held it on one of its feet and began diving into the sand, using head, wings, and the other foot. He said that while yet near the surface, one could see the sand rise to a considerable height due to the rapid action of its wings. He pointed out to me certain marks on the shell of the egg which he claimed are scratches of the bird's claws. I examined these scratches with a magnifier and I am somewhat convinced that they really are scratches of some kind. He told me also that tabon birds deposit their eggs about a meter deep. The man further told me that once he hatched an egg by burying it deep in unhusked rice. It hatched in about fourteen or fifteen days, and to his surprise, after the newly hatched bird dried its feathers, it flew for a distance of about five meters!
>
> I hope that these notes will be of interest to you. Of course, I cannot vouch for the accuracy of his statements, although I think that the man is fairly reliable.

[1] Part IV of this series was published in Philip. Journ. Sci. 19 (1921) 691–703.

GALLICOLUMBA KEAYI (Clarke). Plate 1.

Through the courtesy of Mr. William Parsons, of Manila, I have seen a living male specimen of the Negros puñalada, and Mr. M. Ligaya has made a water-color sketch of it. This bird was sent to Mr. Parsons from San Carlos, Negros, and was in his aviary for some months until made into a skin. The wing, somewhat imperfect, measures 152 millimeters; tail, 100; culmen from base, 22; tarsus, 37; middle toe with claw, 34.

LIMNOBÆNUS FUSCUS (Linnæus).

G. Taguibao and F. Rivera collected a male on April 9 and a female on April 25, 1923, at Santa Maria, Laguna Province, Luzon.

CHLIDONIAS LEUCOPAREIA (Temminck).

On October 15, 1923, I received from Mr. U. C. Roush, of Tacloban, Leyte, a wing and a leg of a whiskered tern, a species so far unknown from Leyte. This is the species formerly called *Hydrochelidon hybrida* (Pallas).

STERNA SINENSIS Gmelin.

Sterna minuta was recorded from Mindanao by Steere,[2] and this is cited by Saunders in the synonymy of *Sterna sinensis*.[3] Mr. E. H. Taylor collected a male of the white-shafted tern on May 1, 1923, at "Saob" (probably Saub), Cotabato Province, Mindanao, which he presented to the Bureau of Science.

PLUVIALIS FULVUS (Gmelin).

On October 15, 1923, I received from Mr. U. C. Roush, of Tacloban, Leyte, a fresh unstuffed skin of a golden plover. Tweeddale[4] recorded this species from Leyte on the basis of a pair collected by Everett.

NUMENIUS ARQUATUS (Linnæus).

A male of the common curlew (Bureau of Science No. 13198) was collected by Andres Celestino near Obando, Bulacan Province, Luzon, on October 12, 1915. I have examined a female of this species that was killed by a hunter in the same region on October 22, 1923.

[2] Birds and Mammals Collected by the Steere Expedition to the Philippines. Ann Arbor, Mich. (1890) 27.

[3] Cat. Birds Brit. Mus. 25 (1896) 114.

[4] Proc. Zool. Soc. London (1877) 549.

MESOSCOLOPAX MINUTUS (Gould).

Macario Ligaya saw three pygmy curlews in a plowed field near Calamba, Laguna Province, Luzon, and collected a female, on September 24, 1922. Francisco Rivera collected a male and a female, near Baliuag, Bulacan Province, on November 2, 1924.

TOTANUS STAGNATILIS Bechstein.

A male of this long-legged sandpiper was collected by Andres Celestino at Obando, Bulacan Province, Luzon, on January 31, 1926.[5] Wing, 135 millimeters; tail, 57; exposed culmen, 39; tarsus, 53; middle toe with claw, 31. Stuart Baker [6] gives the trivial name "marsh sandpiper" to this species. The long slender legs suggest "stilt sandpiper" as appropriate, but that name is in use for *Micropalama himantopus* (Bonaparte), a slightly smaller American species.

ACTITIS HYPOLEUCOS (Linnæus).

A female example of the common sandpiper was collected on Linapacan Island, between Palawan and Culion, on October 10, 1922, by Andres Celestino. This common species has been recorded from twenty-eight islands of the Philippines and can be expected to occur on many more.

CROCETHIA ALBA (Pallas).

I have examined a male sanderling that was collected by Braulio Barboza at Malabon, near Manila, on March 19, 1905.

CALIDRIS TENUIROSTRIS (Horsfield).

A female of the Asiatic knot was collected by Andres Celestino near Obando, Bulacan Province, Luzon, on January 31, 1926. The wing measures 177 millimeters; tail, 76; exposed culmen, 42; tarsus, 33; middle toe with claw, 30.

CALIDRIS ROGERSI (Mathews).

A female short-billed knot, collected by Andres Celestino near Obando, Bulacan Province, Luzon, on January 31, 1926, is in gray winter plumage. The wing measures 162 millimeters; tail, 65; exposed culmen, 34; tarsus, 31; middle toe with claw, 27. This is the third specimen of this species that we have collected near Obando.

[5] See Philip. Journ. Sci. § D 11 (1916) 274 and § D 13 (1918) 8 for previous Philippine records of this species.

[6] Journ. Bombay Nat. Hist. Soc. 28 (1920) 218.

LIMICOLA FALCINELLUS (Pontoppidan).

The first Philippine specimens of the interesting broad-billed sandpiper seem to have been collected in Bohol by Everett, in Palawan by Platen, and in Negros by the Steere Expedition. Later I found it in Cuyo, Cebu, and Luzon. From this it can be seen that the species is well scattered over the Islands when it comes from the north on its way to Australia. Birds of this species are probably more abundant in the fall migration than these few records indicate. Few collectors have paid much attention to Philippine shore and water birds, so that little is known about the occurrence and abundance of such species.

Mathews[7] uses the name *Limicola falcinellus siberica* (Dresser) for Australian examples of the broad-billed sandpiper, and Philippine birds doubtless belong to that race if it differs from the European one.

We collected this species in Cuyo, January 14 and 15, 1903; at Minglanilla, Cebu, November 23, 1906; and at Obando, Bulacan Province, Luzon, November 15, 1910; October 10, 1915; and February 2, 1925. In January, 1926, for the first time we encountered many birds of this species, and the measurements of fifteen specimens collected at that time are here given.

Measurements of Limicola falcinellus (Pontoppidan) from Obando, Bulacan Province, Luzon.

[Measurements are in millimeters.]

Date.	Sex.	Wing.	Tail.	Exposed culmen.	Tarsus.	Middle toe with claw.
1926						
January 13	Male	[a] 97	35	28	22	21
Do	do	104	43	31	23	22
Do	do	105	36	30	20.5	20.5
Do	Female	103	42	34	22.5	22.5
Do	do	106	41	35.5	23	23
January 14	do	105	40	32	22	21
January 16	do	106	46	36	23	22.5
Do	do	108	44	36	24	23
Do	do	106	42	29	22	22
January 31	Male	102	41	30	22	21
Do	do	104	44.5	30	22	22
Do	Female	106	42	33	([b])	20
Do	do	108	46.5	34	22	22
Do	do	100	38	29	20	20
Do	do	111	42	33	23	22

[a] Worn. [b] Broken.

[7] Birds of Australia 3[2] (1913) 279, pl. 165.

DUPETOR FLAVICOLLIS (Latham).

Mr. Mauricio Santiago, of Navotas, Rizal Province, Luzon, secured a specimen of the black bittern at Orani, Bataan Province, Luzon, on September 3, 1924. There are few Philippine records of this species.

QUERQUEDULA QUERQUEDULA (Linnæus).

I have examined a male of the Asiatic blue-winged teal that was collected by Braulio Barboza on Laguna de Bay, Luzon, March 12, 1904.

PITHECOPHAGA JEFFERYI Grant. Plate 2.

I have noted the capture of several individuals of this large endemic eagle; but, as is true of other forest-inhabiting Raptores, it is only rarely that this species can be seen. On July 14, 1926, a female monkey-eating eagle was mounted for the owner at the Bureau of Science. It was stated that the bird had been caught, while it was on the ground drenched with rain, near Pagbilao, Tayabas Province, Luzon. The body of the bird was very thin, and the tail feathers were being molted. The weight was 3.02 kilograms. Length, 1,065 millimeters; expanse of wings, 2,000; wing, 590; tail, 600; tarsus, 123; depth of bill at nostril, 53; chord of culmen from cere, 72. The upper mandible has an extremely long overhang. Iris king's blue; bill black, the base light Payne's gray; legs and feet deep colonial buff, nails black; cere and skin about base of bill black.

PHODILINÆ

Photodilinæ BLANFORD, Fauna Brit. India, Bds. 3 (1893) 268; SHARPE, Hand-list 1 (1899) 300.

Genus PHODILUS I. Geoffroy Saint-Hilaire

Phodilus I. GEOFFROY SAINT-HILAIRE, Ann. Sci. Nat. 21 (1830) 196–203 (*Strix badia*); SHARPE, Cat. Bds. Brit. Mus. 2 (1875) 309.

Pholidus HORSFIELD and MOORE, Cat. Bds. Mus. East India Co. 1 (1854) 80 (error).

Photodilus BLANFORD, Fauna Brit. India, Bds. 3 (1895) 268; SHARPE, Hand-list 1 (1899) 300 (emendation).

Generic characters.—Facial disk incomplete; ear tufts long; tarsus completely feathered; toes without hairs or bristles; inner toe shorter than middle toe; inner side of middle claw with a

sharp edge, not pectinate;[8] tail about half as long as wing; inner web emarginate on four outer primaries.

Only two species of this genus are known; namely, *P. badius* (Horsfield) and *P. assimilis* Hume. The first is found in the eastern Himalayas, Burma, the Malay Peninsula, Java, and Borneo. The second is confined to Ceylon. A specimen from Samar may belong to the type species, but probably it represents an undescribed race. I have no specimen of *P. badius*, so can make no comparisons.

PHODILUS RIVERÆ sp. nov.

Specific characters.—A medium-sized owl; general color of upper parts chestnut with irregular, bold black streaks; scapulars warm buff on outer webs, the tips black; lighter below, cinnamon rufous anteriorly, pinkish cinnamon posteriorly, with a few bold blackish brown shaft stripes; middle of abdomen white.

Type.—No. 13346, male, Bureau of Science. Collected at Loquilocon, Wright (Paranas), Samar, June 9, 1924, by R. C. McGregor and party. Iris brown; bill dull greenish, the tip white; feet gray; nails gray, tips blackish. Length of skin, about 320 millimeters; wing, 220; tail, 115; culmen from base, 35; bill from nostril, 23; tarsus, 54. This species is named for my assistant Francisco Rivera, who flushed the bird from a wooded hillside. The stomach contained the remains of a small snake.

CAPRIMULGUS JOTAKA Temminck and Schlegel.

Among some specimens collected in Mindoro by B. Barboza, Mr. W. Parsons and I found a male of the Japanese nightjar, which was killed near Calapan on March 19 (1908?). This species has been recorded several times from Palawan and once from Calayan, one of the small islands north of Luzon, and will probably be found in Luzon and other large islands.

CHÆTURA DUBIA McGregor.

In April, 1925, large swifts were fairly abundant at Balete Pass (altitude about 1,000 meters), on the road between Nueva

[8] The claw is certainly not pectinate in the only specimen at hand, but this may be an individual variation. Blanford, Fauna Brit. India, Bds. 3 (1895) 268, in a footnote, says that the serration or pectination in good specimens, of which there are between twenty and thirty in the British Museum, is precisely similar to that of *Strix*. Wait, Birds of Ceylon (1925) 245, under the subfamily Photodilinæ, says: "As in the genus *Tyto*, the inner margin of the middle claw is furnished with a slightly serrated, file-like process, or comb."

Ecija and Nueva Vizcaya Provinces, Luzon. The birds were most in evidence in the early morning and early evening. They flew from one side of the mountain to the other, passing fairly low over the small cleared area near the rest house. On April 10, Dr. Otto Bartels, of Manila, shot a female (Bureau of Science No. 13344), which is similar to the female type of *Chætura dubia* from Mindoro, but has longer wings and tail.

XEOCEPHUS CYANESCENS Sharpe.

Andres Celestino collected a slightly immature male of the large blue flycatcher on Bantac, a small island about 16 kilometers northeast of Busuanga, Palawan Province, on October 12, 1922. This specimen closely resembles the young male described by me some time ago,[9] except that in the former the head, the chin, and the throat are fully feathered and of almost the same blue as in the adult.

CHLOROPSIS FLAVIPENNIS (Tweeddale).

A female of the yellow-quilled leafbird was collected by Andres Celestino, near Davao, Mindanao, on September 26, 1922. I can find no difference between this specimen and two females that were collected in Cebu in October.

KITTACINCLA NIGRA Sharpe.

Andres Celestino collected a slightly immature male of the Palawan shama on Bantac Island,[10] Palawan Province, on October 12, 1922. This specimen has most of the black and white plumage of the adult, but some of the wing quills and their coverts are edged with tawny to ochraceous tawny and the flanks are slightly tawny. The three outer, white rectrices are fully grown, but the inner, black ones are shorter than the outermost white pair. In a young female collected at Puerto Princesa, June 27, 1910, by Worcester and Celestino, the entire head, neck, back, chin, throat, and breast are spotted.

Genus PRIONOCHILUS Strickland

Prionochilus STRICKLAND, Proc. Zool. Soc. London (1841) 29.
Anaimos REICHENBACH, Handbuch der speciellen Ornithologie, Scansoriæ (1853) 245.

In the original generic description Strickland assigns three of Temminck's species to *Prionochilus* and enumerates them as *P. percussus*, *P. thoracicus*, and *P. maculatus*. Sharpe[11] gives

[9] Philip Journ. Sci. 18 (1921) 79.
[10] See antea, under *Xeocephus cyanescens*.
[11] Cat. Bds. Brit. Mus. 10 (1885) 63.

the type as "P. ignicapillus," doubtless meaning *Dicæum ignicapillum* Eyton, a species not mentioned by Strickland. Oberholser [12] mentions the fixation of the type, by Gray, in 1842, as *Pardalotus percussus* Temminck. He rejects *Prionochilus* because of *Prionocheilus* Chevrolat, 1837, used for a genus of Coleoptera. Oberholser proposes to use *Anaimos* Reichenbach, 1853. This name is mentioned by Sharpe, but the date is misprinted 1883. (This error is repeated by both Oberholser and Hartert.) Stuart Baker [13] and Hartert retain *Prionochilus*, and Hartert [14] says—

> Oberholser rejects the name *Prionochilus* because of the earlier name *Prionocheilus*, and adopted the name *Anaimos* Reichenbach, 1883. Though the two names are evidently only different Latin renderings of the same Greek name, I suppose they are easily distinguishable and should both be accepted. No nomenclatorial rule demands the contrary.

PRIONOCHILUS PARSONSI sp. nov. Fig. 1. b.

Specific characters.—Male similar to the male of *Prionochilus olivaceus* Tweeddale, but lores, cheeks, and sides of throat and of breast black, not mouse gray. No sign of white on lores. In the female the black is replaced by dark mouse gray.

Type.—No. 13345, male, Bureau of Science. Collected at Malinao, Tayabas Province, Luzon, January 9, 1926, by Francisco Rivera.

Description of type.—Upper parts greenish yellow (near Ridgway's pyrite yellow), extending to sides of neck, and a wide line under eye; lores and sides of chin, throat, and breast black; center of chin, throat, and breast, and abdomen and under tail coverts white; flanks black and white, lightly washed with olivaceous; thighs black and white; axillars, wing lining, and long pectoral tufts white. Bill, legs, and nails black. Wing, 55 millimeters; tail, 30; culmen from base, 11; tarsus, 14.5.

Female.—Malinao, Tayabas Province, Luzon; January 9, 1926; Francisco Rivera, collector. Collection of W. Parsons. Similar to the male, but the black replaced by dark mouse gray, much darker than the gray areas of *P. olivaceus*. Bill, legs, and nails black. Wing, 53 millimeters; tail, 24; culmen from base, 10; tarsus, 15.

[12] Smiths. Misc. Colls. article 7, 60 (1913) 22. Article 7 was published on October 26, 1912.

[13] Hand-list Bds. Indian Empire (1923) 125.

[14] Nov. Zool. 27 (1920) 430, footnote.

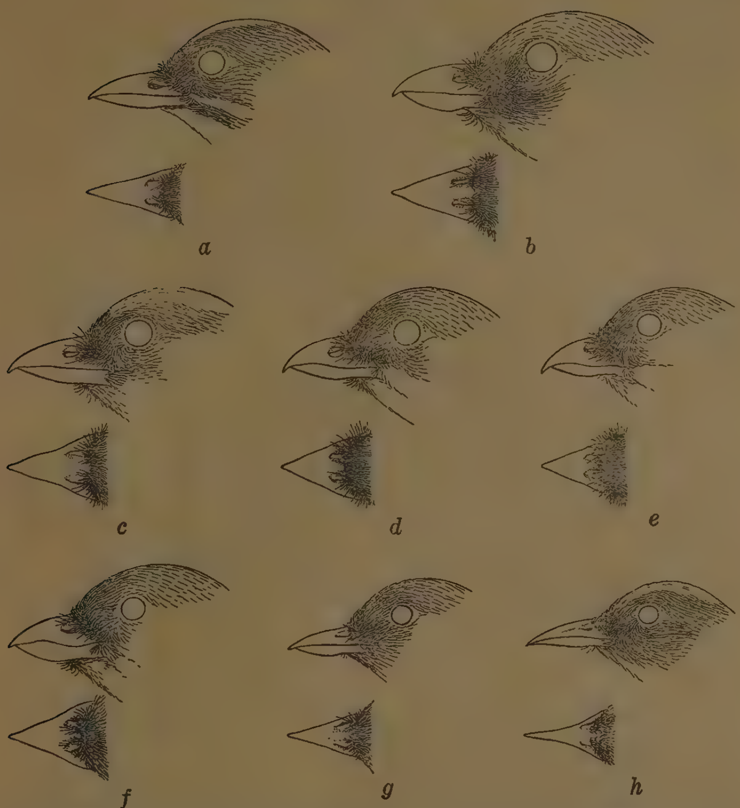


FIG. 1. Bills of various species of *Prionochilus* and of the genotype of *Dicæum; a, Prionochilus johannæ* Sharpe; *b, P. parsonsi* sp. nov.; *c, P. anthonyi* McGregor; *d, P. quadricolor* Tweeddale; *e, P. inexpectatus* Hartert; *f, P. æruginosus* Bourns and Worcester; *g, P. squalidus* (Burton); *h, Dicæum cruentatum* (Linnæus).

The type of *Prionochilus olivaceus* came from Dinagat Island, east of Leyte and north of Mindanao, and the species has been recorded from Basilan, Mindanao, Bohol, Samar, and Leyte. I have at hand three males and two females from Basilan, one female from Bohol, and one male from Samar. These specimens show neither sexual nor individual differences, except that the gray of the lower parts is slightly darker in the males. In all except the male from Samar the bases of the loral feathers are white. In *P. parsonsi* there is no sign of white on the lores,

and the sexes are strikingly different in color. This species is named for Mr. William Parsons, of Manila, in recognition of his interest in Philippine ornithology.

In the Bureau of Science collection there is a male *Prionochilus olivaceus* of the year that was collected by Bourns and Worcester at Catbalogan, Samar, on August 15, 1892. This probably indicates that eggs were laid early in June.

Prionochilus samarensis Steere [15] is described as differing from *P. olivaceus* "in having the breast and sides of the throat ash brown, nearly snuff brown, instead of ashy olive." Grant [16] did not recognize this as a valid species, and until I see more material I shall follow Grant.

Subgenus POLISORNIS novum

Type, *Prionochilus anthonyi* McGregor.

Family Dicæidæ; differs from *Prionochilus* Strickland (type, *Pardalotus percussus* Temminck) in having the bill shorter and wider. Serrations of the bill obsolete and extending for a shorter distance from the tip; those of lower mandible scarcely distinguishable. Loral bristles numerous, extending forward and upward, partly protecting but not concealing the nostrils; no bristles on nasal operculum. Tenth primary lacking, the outermost about 3 millimeters short of tip of wing. Tail square, without white spots.

Seemingly, *Prionochilus quadricolor* and *P. bicolor* belong to this subgenus also; surely, Sharpe's [17] assignment of them to different genera is incorrect.

Sharpe,[18] in the monograph of the Dicæidæ, subordinates *Pachyglossa* Hodgson (1843) type *Micrura melanoxantha*, *Piprisoma* Blyth (1844) type *Pipra squalida*, and *Anaimos* Reichenbach (1853) type *Pardalotus thoracicus* as synonyms of *Prionochilus* Strickland (1841) type *Pardalotus percussus*. Oates [19] recognizes *Prionochilus*, *Pachyglossa*, and *Piprisoma* as valid genera and adds *Acmonorhynchus*, type and only species *Prionochilus vincens*. Dubois [20] unites all under *Prionochilus*. Sharpe [21] recognizes all of these genera except *Anaimos*. The species of

[15] Birds and Mammals of the Steere Expedition (1890) 22.
[16] Ibis (1897) 239.
[17] Hand-list 5 (1909) 31.
[18] Cat. Birds Brit. Mus. 10 (1885) 63.
[19] Fauna Brit. India, Bds. 2 (1890) 381–386.
[20] Syn. Av. 1 (1902) 674.
[21] Hand-list 5 (1909) 30–32.

these genera as arranged by Sharpe, with the addition of three Philippine species not known to him, are the following:

Prionochilus:
- *percussus* (Temminck), genotype.
- *ignecapillus* (Eyton).
- *xanthopygius* Salvadori.
- *johannæ* Sharpe, synonym, *plateni* Blasius. Palawan.
- *thoracicus* (Temminck).
- *maculatus* (Temminck).
- *obsoletus* (Müller and Schlegel).
- *olivaceus* Tweeddale. Philippines.
- *parsonsi* sp. nov. Not known to Sharpe.
- *everetti* Sharpe.
- *anthonyi* McGregor. Not known to Sharpe.
- *bicolor* Bourns and Worcester. Philippines.
- *inexpectatus* Hartert. Philippines.

Acmonorhynchus:
- *vincens* (Sclater), genotype.
- *æruginosus* (Bourns and Worcester). Philippines.
- *affinis* Zimmer. Not known to Sharpe.
- *quadricolor* (Tweeddale). Philippines.
- *aureolimbatus* (Wallace).
- *sangirensis* (Salvadori).
- *annæ* Büttikofer.

Piprisoma:
- *squalidum* (Burton), genotype.
- *modestum* (Hume).

Pachyglossa:
- *melanoxantha* Hodgson, genotype.

I have one specimen of *Prionochilus ignecapillus;* this species resembles *P. johannæ* in the color pattern as well as in the rather slender bill and short distal primary. *Prionochilus maculatus,* of India, has a shorter distal primary and the bill is similar to that of *P. ignecapillus;* above there is a similar red crown patch, but the general color is green instead of blue; the colors of the underparts are white, yellow, and dark olive, arranged in a pattern similar to that of *P. olivaceus* of the Philippines. The last-named species has a wider bill. I have no specimen of *P. percussus.*

Prionochilus æruginosus Bourns and Worcester, transferred to *Piprisoma* by Grant,[22] resembles *Piprisoma squalidum* (genotype)[23] in having no tenth primary and in the pattern of the

[22] Ibis (1895) 454.

[23] I have examined but one specimen, loaned by the United States National Museum.

dull streaked plumage. Grant says, on the basis of a single specimen, that the Bourns and Worcester species has "the nostrils perfectly bare of hairs." This is not true of numerous specimens before me, for they have as many loral hairs, overhanging and partly concealing the nostrils, as do the typical species of *Prionochilus*, and some have more. There are also short hairs on the upper border of the nasal operculum. The Bourns and Worcester species has a very stubby bill, actually equal in length to that of *Piprisoma squalidum*, but much wider and deeper; the length of gonys is equal to a ramus. This species does not seem to be a *Piprisoma;* Sharpe put it in *Acmonorhynchus*, a genus that was described for *Prionochilus vincens* with the following diagnosis: [24]

> It differs from both these genera [*Prionochilus* and *Pachyglossa*] in possessing only nine primaries. From *Dicæum* it may be recognized by its very large, coarse bill, and from *Piprisoma* by its rounded tail and the numerous hairs which cover the nostrils.

In Oates's text figure showing the head of *Acmonorhynchus vincens* the nostril appears to be entirely covered by hairs, but the drawing is too small to show whether these hairs spring from the lore or partly from the upper border of the nostril.

Prionochilus æruginosus has a square tail and a white spot on the inner web of the outermost two rectrices. The color pattern is different from that of *Acmonorhynchus vincens*, judging from the descriptions; I have seen no specimen of the latter.

Hartert [25] calls attention to the difficulty in using the key to the genera of Dicæidæ,[26] because *Prionochilus* falls in the section "With a distinct bastard primary," whereas some of the species placed in that genus by Sharpe have no first primary. Hartert says further—

> If the absence or presence of a distinct bastard primary is a good generic character, the species without a distinct bastard primary must either be united with *Dicæum*, or be kept generically distinct under the name of *Pachyglossa* Blyth.

Unfortunately, I have never seen an example of *Pachyglossa*, but after reading Oates's diagnosis [27] I assumed that *Pachyglossa* offers as much difficulty to the species in question as does *Prionochilus*.

[24] Oates, Fauna Brit. India, Bds. 2 (1890) 381, fig. 105.
[25] Novit. Zool. 2 (1895) 65.
[26] Cat. Bds. Brit. Mus. 10 (1885) 2.
[27] Fauna Brit. India, Bds. 2 (1890) 485.

Without any desire to increase the number of genera among the known species of this group, I propose two new subgeneric names as follows:

Polisornis subg. nov., type, *Prionochilus anthonyi* McGregor; other species of the subgenus, *Prionochilus quadricolor* Tweeddale, *P. bicolor* Bourns and Worcester, *P. inexpectatus* Hartert. From "Polis," type locality of the type species, and "ornis."

Bournsia subg. nov., type, *Prionochilus æruginosus* Bourns and Worcester; other species of the subgenus, *Acmonorhynchus affinis* Zimmer. Named for Frank S. Bourns, an American physician and naturalist, a member of the Steere Expedition and of the Manage Expedition.

Prionochilus johannæ, confined to Palawan, is the only Philippine species that is a strictly typical member of the genus; in other words, *Prionochilus* is not represented in the Philippines by a typical species, outside of Palawan.

If all of the Philippine species of the thick-billed Dicæidæ be kept in *Prionochilus* they should be arranged as follows:

Genus *Prionochilus:*
- Subgenus *Prionochilus*—
  - *johannæ* Sharpe.
  - *olivaceus* Tweeddale.
  - *parsonsi* sp. nov.
- Subgenus *Polisornis*—
  - *anthonyi* McGregor.
  - *quadricolor* Tweeddale.
  - *bicolor* Bourns and Worcester.
  - *inexpectatus* Hartert.
- Subgenus *Bournsia*—
  - *æruginosus* Bourns and Worcester.
  - *affinis* (Zimmer).

STURNIA PHILIPPENSIS (Forster).

Three specimens of the violet-backed starling were collected by Andres Celestino on Linapacan Island, between Palawan and Culion, on October 10, 1922. This species has been recorded from Palawan and from a few other islands of the Philippines. It appears during migration and may be very abundant for a few days. A somewhat similar species, *Sturnia sinensis* (Gmelin), has been recorded from Calayan and Luzon, and should be watched for when the commoner species appears.

ILLUSTRATIONS

PLATE 1

Gallicolumba keayi (Clarke); $\times \frac{3}{8}$. (Water-color drawing from a specimen in the flesh, by Macario Ligaya.)

PLATE 2

Pithecophaga jefferyi Grant. (Photographs of a living bird from Pagbilao, Tayabas Province, Luzon, by Eustaquio Cortes.)

TEXT FIGURE

FIG. 1. Bills of various species of *Prionochilus* and of the genotype of *Dicæum;* $\times 1\frac{1}{3}$. (Drawings by Macario Ligaya.)

- *a, Prionochilus* (*Prionochilus*) *johannæ* Sharpe; Palawan, male.
- *b, Prionochilus* (*Prionochilus*) *parsonsi* sp. nov.; Luzon, male; drawn from the type.
- *c, Prionochilus* (*Polisornis*) *anthonyi* McGregor; Luzon, male; drawn from the type.
- *d, Prionochilus* (*Polisornis*) *quadricolor* Tweeddale; Cebu, male.
- *e, Prionochilus* (*Polisornis*) *inexpectatus* Hartert; Luzon, male.
- *f, Prionochilus* (*Bournsia*) *æruginosus* Bourns and Worcester; Luzon, female.
- *g, Prionochilus* (*Piprisoma*) *squalidus* (Burton); Assam, India, female, A. M. Primrose, collector. United States National Museum No. 263739.
- *h, Dicæum cruentatum* (Linnæus), genotype; Trong (or Trang), Siam, male, W. L. Abbott, collector. Bureau of Science No. 10072; ex United States National Museum No. 154193.

PLATE 1. GALLICOLUMBA KEAYI (CLARKE).

PLATE 2. PITHECOPHAGA JEFFERYI GRANT.

SOME PHILIPPINE AND MALAYSIAN MACHÆROTIDÆ (CERCOPIOIDEA)

By C. F. Baker

Of Los Baños, Philippine Islands

FOUR PLATES

In a previous paper [1] an attempt was made to review the true machærotids of Malaysia and the Philippines. Without sufficient material it was impossible to include in that paper the allies of *Enderleinia*. In the seven years intervening, some remarkable relatives of *Enderleinia* have been found in the Philippines and considerable Australian material of the same group has come to hand, some collected by Mr. H. Peterson, and some loaned by the Australian Museum at Sydney and by the South Australian Museum at Adelaide.[2] This has made possible a rearrangement of the whole group. Certain genera previously supposed to be Cercopidæ s. str. (=Aphrophorinæ auctt.) have been found to be true machærotids. While the Australian species are still in more or less confusion, the relationships of the genera are now clear, and it is possible to recognize *Hindola* as the typical genus of its subfamily with various other genera grouped closely about it.

Both *Clastoptera* (Neotropical) and *Iba* (Palæotropical) present some striking resemblances to certain machærotids in their elongate scutella and tegminal venation and appendices. These genera are, however, as far from Machærotidæ as from Cercopidæ s. str. and should constitute a separate family. Besides, they are not tube-dwellers. No representative of the Machærotidæ is known from the Americas.

In the Cercopioidea, just as in the Jassoidea, there is in general a remarkable uniformity, even through series of types quite diverse otherwise, in the venation of the hind wings, in strong contrast with the high degree of modification in the venation of the tegmina. Therefore, where distinct departures occur in the wing venation, these are of great importance in taxonomy,

[1] Philip. Journn. Sci. 15 (1919) 67–78, pls. 1–3.

[2] The Australian material will be fully treated in a forthcoming paper.

as in the eupterygids, balcluthids, and machærotids. In other characters the machærotids present the greatest range of body structure in the Cercopioidea, but certain venational characters are highly uniform and diagnostic.

Superfamily CERCOPIOIDEA

Key to families.

a^1. Outer fork of radius in hind wings always present (sometimes broken at apex), thus forming a supernumerary (first) apical cell, the cubitus apically forked or simple; claval veins (if present) usually distant and without connecting cross vein; scutellum comparatively small and short (except in Clastopteridæ).

b^1. Pronotal margin between eyes usually straight or slightly arcuate; front commonly more or less swollen apically; supraantennal ridges thickened and lobate; pronotum commonly strongly enlarged and much broader than head, and with anterolateral margins usually as long as or longer than posterolateral.
Tomaspididæ (=Cercopinæ auctt., =Rhinaulacinæ auctt.).

b^2. Pronotal margin between eyes usually strongly arcuate or subangulate; front usually swollen basally, if at all; supraantennal ridges not lobate, or greatly thickened; pronotum never greatly enlarged and rarely much wider than head, the anterolateral margins usually much shorter than the posterolateral.

c^1. Clavus narrowly acute or subacute apically; corial appendix either a narrow continuous membranous margin or wanting, never bent inward beyond clavus to overlap at end of body; corial venation various, but never as in Clastopteridæ; scutellum usually much shorter than pronotum.
Cercopidæ s. str. (=Aphrophorinæ auctt., =Ptyelinæ auctt.).

c^2. Clavus obliquely truncate at apex; corial appendix divided into two very broad subequal portions, these at rest infolded at end of the short and broad body to overlap; fork of radius in wing forming a very short first apical cell considerably before apex; cubitus in wings not forked apically; corium with three apical cells and two (or less) subapicals; scutellum longer than pronotum.
Clastopteridæ (including Ibaini).

a^2. Outer fork of radius in wing always absent, therefore no supernumerary (first) apical cell; claval veins (when two) adnate at middle or with a connecting cross vein; scutellum as long as or longer than pronotum, either simply long acuminate, or greatly elevated posteriorly and with a strongly curved free apical spine projecting caudad .... **Machærotidæ**.

MACHÆROTIDÆ

Key to subfamilies.

a^1. Scutellum not raised apically or with free apical spinous appendage; anterolateral margins of pronotum always very short, far shorter than posterolateral margins, the hind margin always more or less

deeply emarginate; anterior margin of pronotum strongly extended between eyes; head never broader than anterior width of pronotum and never strongly roundly swollen in front of eyes, usually obtuse-angulate; cubitus in hind wing apically forked; four apical corial cells arranged obliquely or even transversely to long axis of corium, the third from within never pedicellate or strongly projecting beyond and apically bounding fourth (outer).

Hindoliinæ (= Enderleiniinæ).

*a*². Scutellum usually greatly raised apically, always with a free apical spinous appendage extended caudad; anterolateral margins of pronotum longer than posterolateral, the hind margin not or but very shallowly emarginate; anterior margin of pronotum but very slightly extended between eyes; head somewhat broader than anterior width of pronotum and strongly, usually roundly, swollen and extended in front of eyes; cubitus in hind wings not forked; four apical corial cells arranged nearly longitudinally (in line with long axis of tegmen), the third from within pedicellate and extending strongly beyond and apically bounding fourth (outer).

*b*¹. Form slender, body of scutellum high arched posteriorly with strong dorsal furrow; pronotum without laminately extended lateral angles; anterior margin of pronotum somewhat angulate between eyes .... **Machærotinæ.**

*c*¹. Frons not vertically produced; hind tibiæ without lateral spur.

Machærotini.

*c*². Frons vertically angularly produced to high above head; hind tibiæ with one lateral spur........ **Sigmasomini.**

*b*². Form very thick and stout; body of scutellum nearly flat and with dorsal furrow subobsolete; pronotum with lateral angles produced into high, thin, spreading laminæ; anterior margin of pronotum broadly, gently arcuate between eyes........ **Maxudeinæ.**

HINDOLIINÆ

Key to genera.

*a*¹. Clavus narrowly acute apically, its terminal appendix very small and narrow; body more elongate, not clastopteroid, the tegmina never bent inward beyond clavus (Hindolini).

*b*¹. Scutellum basally strongly convexly raised above highest part of pronotum; pronotum smooth, finely punctured; crown of head nearly vertical, the head very short and broadly rounded (profile) from base to apex; tegmen with numerous irregular cells occupying apical half; two claval veins adnate at middle.

Apomachærota Schmidt.

*b*². Scutellum basally never raised above highest part of pronotum; crown of head usually oblique; tegmen with three or four very regular apical cells and two or three anteapicals.

*c*¹. Claval veins separated and joined at middle only by a cross vein; scutellum with an elongate fossa.

*d*¹. Anteapical cells elongate and subequal in length; cubitus distant from claval suture throughout; both claval veins forked apically. (East Africa.)........ **Neuromachærota** Schmidt.

d^2. Anteapical cells broad, the second much shorter than the others; cubitus apically approximate to claval suture; claval veins simple; pronotum strongly transversely wrinkled; tegminal veins with scattered black granulations; head as wide as pronotum, the latter rather broadly arcuate-margined between eyes; scutellum shorter than pronotum. (Ceylon.)
Machæropsis Melichar.

c^2. Claval veins always adnate for some distance at middle.

d^1. Scutellum longer than pronotum and apically with two high, longitudinal, raised edges, forming a large, deep fossa; hind tibiæ with two strong subapical spurs. (Togo.)
Enderleinia Schmidt.

d^2. Scutellum simple or with but slight discal depression; hind tibiæ with but one subapical spur (though frequently also with a reduced subbasal spur.)

e^1. Cubitus lying for some distance at middle, on the claval suture, strongly curved, the base and apex distant from claval suture; corium with two subapical cells, second short; scutellum longer than pronotum; head a little more than half the width of pronotum.......... **Serreia** g. nov.

e^2. Cubitus distant from claval suture and nearly straight; corium with three anteapical cells, the middle hardly half the length of the other two; scutellum shorter than pronotum; head but slightly narrower than pronotum.

f^1. Scutellum with a large, shallow, subcircular depression occupying a large part of disk; crown, pronotum, and scutellum with very large, deep, crowded punctures; claval and part of corial veins with scattered dark granules, some of which near apex are bullate; all the veins strong and dark; crown (profile) lying in plane of anterior slope of pronotum and not at all depressed; hind tibia with a very large spur at middle.......... **Parahindola** g. nov.

f^2. Scutellum plane or slightly convex, smooth; hind tibial spur always nearer to apex than to base.

g^1. Body slenderer, not thickened and robust; head very little, if any, narrower than pronotum; surface of the largely subhyaline tegmina nearly plane, veins usually weak and indistinct, pronotum coarsely or finely punctured, and often with indications of transverse rugæ or wrinkles, but the puncturing usually predominant; sexes very similar.
Hindola Stål (=*Pectinariophyes* Kirkaldy=*Polytrichophyes* Schmidt=*Modiglianella* Schmidt=*Taihorina* Schumacher, =*Quinquatrus* Distant, =*Xenaias* Distant).

g^2. Body thick and robust; head appreciably narrower than pronotum, the latter strongly transversely wrinkled with more or less of intermingled punctures; surface of tegmina strongly irregular with deep depressions be-

tween the strong veins, the tegmina as a whole rather strongly convex; sexes strongly dimorphic.
Chaetophyes Schmidt.

*a*². Clavus broad apically, obliquely subtruncate, its terminal appendix short but broad; form of body rather strikingly clastopteroid, short and compact, the tegmina apically bent across apex of body behind clavus, and there overlapping; crown broadly rounded on to the strongly convex face (*Hindoloidesini*).

*b*¹. Veins scattered granulate on the subhyaline corium; crown almost vertical, very short, transverse; corium with three small apical cells; corial appendix not yet described or figured.
Polychætophyes Kirkaldy.[3]

*b*². Veins not granulate, the discal veins very obscure except by transmitted light; crown oblique, more elongate; terminal corial appendix of great width with subparallel inner and outer margins, and reaching entirely across apex of tegmina; corium with apical cells entirely absent .... **Hindoloides** Distant.

Genus CONMACHÆROTA Schmidt

In a synopsis of the Malaysian species of the genus *Machærota* Burmeister[4] the species were divided into two groups, the first comprising those with the claval vein apically forked (possibly two partly adnate claval veins) and the second those with the claval vein (single) simple. Between the writing of this paper and its publication, Schmidt[5] separated the first group as a distinct genus under the name *Conmachærota*, with *notoceras* Schmidt as the type. Two new species of this group have recently been encountered in the Philippines, and their relation to the species previously discussed is given in the following key.

Key to species of the genus Conmachærota Schmidt.

*a*¹. Pronotum and scutellum in profile very broad, the narrow, basal portion of scutellum very short, basal portion of scutellum with a prominent yellow stripe on either side; length of crown much more than half the width between eyes; greatest profile width of scutellum into length of spine twice or a little more.

*b*¹. Scutellum in profile with greatest width much less than length; basal portion forming a distinct "neck;" its dorsal sulcus reaching about half the length of body of scutellum.

*c*¹. Females pale in color, males much darker; body densely fine pubescent; entire scutellum about twice as long as head and thorax together; crown anteriorly rather broadly rounded.
C. notoceras Schmidt.

[3] Possibly founded on males of *Hindola* or *Chaetophyes*, and may not belong to this tribe.

[4] Philip. Journ. Sci. 15 (1919) 69.

[5] Stett. Ent. Zeit. 79 (1918) 371.

c^3. Female dark chocolate brown, same as males; body less densely pubescent; entire scutellum distinctly more than twice longer than head and thorax together; crown anteriorly subangulate at apex.. **C. mindanaensis** sp. nov.

b^2. Scutellum in profile with greatest width about equal to length, basal portion not forming a distinct "neck;" its dorsal sulcus reaching about three-fourths of body of scutellum; crown anteriorly subangulate at apex... **C. philippinensis** Baker.

a^2. Pronotum and scutellum in profile very narrow, basal narrow portion of scutellum very long, this due to the strong flattening of both pronotum and scutellum; basal portion of scutellum without lateral yellow stripes; length of crown about half the width between eyes, anterior margin strongly subangulate; greatest profile width of scutellum into length of spine four times...................... **C. attenuata** sp. nov.

CONMACHÆROTA MINDANAENSIS sp. nov.

Female.—Length to end of abdomen, 4.75 millimeters; to end of spine, 7.5; length of spine alone, 3.5.

Color of body very deep chocolate brown, the body of scutellum much paler, the spine golden brown. Broad central band of front shining black. Pale yellow are five oblique lines on sides of front, curved lateral stripes on body of scutellum, its apical margin below spine, the usual dorsal spot at base of spine, entire basal segment of abdomen and remaining tergites at middle, and basal article of hind tarsus except extreme base and apex.

Sculpturation very similar to that of *philippinensis*, but the median carina of pronotum is strong throughout, strongest on middle third. Scutellar sulcus (fig. 6) broader and shallower than in *philippinensis*. Crown subangulate anteriorly (fig. 5). Diagnostic characters otherwise as stated in the key. Proportions in profile as in fig. 4.

Male.—Length to end of abdomen, 4 millimeters; to end of tegmina, 5; to end of spine, 6.5.

Colors same as in the female, differing in this respect from both *notoceras* and *philippinensis*.

Appears to be common in northern Mindanao, specimens coming from Surigao, Surigao Province, and from Iligan, Lanao Province (*Baker*).

CONMACHÆROTA ATTENUATA sp. nov.

Male.—Length to end of abdomen, 3.5 millimeters; to end of tegmina, 5; to end of spine, 6.5.

Color very deep chocolate brown, body of scutellum not paler, the spine golden brown. Frons yellow with dark oblique stripes on sides; only the apex of crown (extreme base of frons) shining

black. Sides of body of scutellum entirely without yellow stripes, but area of sulcus paler, and hind margin narrowly yellowish. Lateral margins of pronotum very narrowly yellowish. Fore and middle legs pale fulvous. Hind basitarsus, except extreme base and apex, yellow. Abdomen without yellow markings except on basal tergite. Venation on apical half of tegmina darker than in either *notoceras, philippinensis,* or *mindanaensis.*

Sculpturation very similar to that of *mindanaensis.* Scutellar sulcus (fig. 3) short and small, less than one-half length of body of scutellum. Crown (fig. 2) more strongly angulate anteriorly. Diagnostic characters otherwise as in synopsis above. The profile proportions (fig. 1) are unique in this group.

A single specimen from Zamboanga, Mindanao (*Baker*).

Genus SERREIA novum

Diagnostic characters as given in the synopsis above. In general form this genus resembles the robust and strongly humpbacked *Apomachærota* and its allies rather than the slenderer, cercopioid *Hindola* and allies. Of the latter it resembles *Chaetophyes* in having the surface of the tegmina very uneven, with a deep, sharply curved, longitudinal depression on base of corium, and the apical and subapical cells concave. The corial appendix is much larger and reaches nearer to apex of corium (fig. 11) than in *Hindola* or any of its near relatives. The hind femora are shallowly concave on lower surface, subequal in length to hind tarsi, and much shorter than their tibiæ; hind tarsi with first article (seen from above) subequal to remaining two together; hind tibiæ with subapical spur very stout, the basal minute. The rostrum slightly surpasses the middle coxæ.

This notable genus is dedicated to a notable man, Mons. Paul Serre, Consul of France, "citizen of the world," formerly resident of many tropical countries, now in Auckland, New Zealand. He is accomplished in agricultural science and takes an enthusiastic interest in all scientific endeavor. He is widely known for his thoroughgoing monographs on Havana tobacco and New Zealand hemp.

SERREIA NOTABILIS sp. nov.

Female.—Length to end of closed tegmina, 7 millimeters; width of head, 2; of pronotum, 3; length of tegmen, 5.75; width at end of clavus, 3.5.

Color deep chocolate brown, head, pronotum, and tegmina smooth and shining. Face and all below somewhat paler and with a yellowish cast; the slight convexity before apex of scutellum with a sordid yellowish transverse mark. Frons without oblique dark lateral arcs. Tegmen hyaline, the yellowish veins margined throughout middle of corium with minute brown dots, with two discal groups of such dots, the larger proximal one extending to costal margin, the distal smaller one at base of the anteapical cell; the veins bordering apical cells broadly margined with very deep chocolate brown, cubital veins with several larger superposed brown dots. Corial appendix smoky at base and at apex. Clavus suffused with pale yellowish which narrowly invades corium, the inner apical fork of claval vein margined with minute brown dots.

Frons shining, minutely obscurely wrinkled with shallow, oblique lateral folds near base; loræ with scattered large punctures. Clypeus (fig. 10) strongly compressed apically, forming a high median ridge, the lateral surfaces of this portion concave and coarsely transversely wrinkled. Crown shining, but the surface very uneven due to low, coarse, indistinct wrinkles of no regular arrangement. In direct view vertical to crown (fig. 7), the length of crown is more than three-fourths width between eyes, the distance between ocelli is less than length of true vertex; exposed superior surface of front as long as greatest width. Pronotum (fig. 8) smooth and shining with obsolescent coarse transversal wrinkles and large scattered punctures; no median carina. Length of pronotum two-thirds of its width, the anterior margin evenly arcuate, the posterior shallowly emarginate. Scutellum (fig. 9) evenly convex, smooth and shining with scattered obsolescent punctures, lying in the general curve of pronotum, and with the apical profile margin bisinuate. Venation of tegmen and wing as shown in figs. 11 and 12. Clavus near apex with a large, round, strongly convex, concolorous bulla.

Male.—Length to end of closed tegmina, 5.5 millimeters; width of head, 1.5; of pronotum, 2.5; length of tegmen, 4.5; width at end of clavus, 2.5.

Color darker than in female, the scutellum piceous. Veins of tegmina darker, the brown margins of apical veins narrower, the claval bulla shining black. Face and all below black or

piceous, legs a little paler. Puncturation of pronotum and scutellum deeper and the latter with quite obvious coarse transverse wrinkles.

Two specimens of this remarkable insect were taken near Zamboanga, Mindanao, and fortunately represent the two sexes.

A single male specimen which must be referred here, at least until the corresponding female is known, was taken on Mount Maquiling in central Luzon. It differs in having the hind legs pale yellowish, and the claval bulla not conspicuously shining black. It may bear the varietal name *luzonensis*.

Genus PARAHINDOLA novum

Diagnostic characters as in above generic synopsis. No member of the *Hindola* group of species possesses the unique scutellar structure of *P. borneensis*, and none possesses the extremely coarse sculpturation uniformly covering crown, pronotum, and scutellum. The shallow scutellar depression is roundish and saucer-shaped, but has a thickly obtuse and little raised rim. The subobsolete median pronotal carina is more distinct near the anterior margin. There is a greater number of cross veins in the outer (radial) cell, the cubital vein is more strongly curved, and the corial appendix is much longer than in *Hindola*. Hind tibiæ with a very large and long spur inserted at middle, only a minute rudiment of the subbasal spur remaining. Basal article of hind tarsi as long as the two distal together.

While in all species of *Hindola* known to me the general plane of face is nearly horizontal and lies nearly in line with the long axis of the body, in *Parahindola* it is distinctly oblique to the axial line.

PARAHINDOLA BORNEENSIS sp. nov.

Female.—Length to end of closed tegmina, 6.5 millimeters; width of head, 2.5; of pronotum, 2.75; length of tegmen, 5; width at end of clavus, 2.

Color stramineous; front chocolate brown; femora except apex piceous, remainder of legs pale brownish, hind tibiæ yellowish. Abdomen pale yellowish basally. Tegmina with basal fourth pale bronzy brownish, remainder hyaline; claval and basal corial veins indistinct, remainder dark and distinct; claval and basal corial veins with scattering superposed dark brown

dots and a sparse row of such dots about the entire outer corial periphery; veins on apical half of corium more or less broadly margined with deep brown.

Front a little shining above, subopaque below, very gently convex, the surface microscopically crowded lacunose with some scattered indistinct punctures on median area. Subantennal portion of cheek thickly rugose, subocellar area transversely wrinkled, loræ coarsely punctured. Crown (fig. 13) like pronotum and scutellum, with very coarse deep and crowded irregular punctures. Interocellar distance nearly equal to twice length of true vertex, superior face of front (vertical view) much wider than long, and at a little less than half its length from base with a strongly raised, arcuate transverse ridge, the surface posterior to this having the large punctures grouped in deeper cavities. Pronotum with median carina distinct only on anterior fourth; length somewhat less than two-thirds width, anterior margin medially subangulate, posteriorly very obtuse angulately emarginate. Surface of scutellum in profile view (fig. 14) nearly plane and lying considerably below the posterior convexity of pronotum, the apex depressed before the acuminate tip. Length of scutellum little greater than that of pronotum. Venation of tegmen as shown in fig. 15, the wing venation normal for this group. Tegmen shining, the clavus and basal half of corium with large, scattering shallow punctures. The two large brown spots on the two middle apical veins are somewhat bullate and the veins appear to be somewhat bent within them (not shown in the figure).

A single specimen taken at Sandakan, British North Borneo (*Baker*).

Genus HINDOLA Kirkaldy

Hindola was described by Stål[6] as *Carystus* (praeocc.) and based upon *Ptyelus viridicans* Stål,[7] a common species of Singapore. Later Spangberg[8] described four species from Australia, none of which appears to be true *Hindola*. Never having seen true *Hindola*, Kirkaldy[9] described *Pectinariophyes*, which is *Hindola*. *Polychætophyes* Kirkaldy is questionably a clastopteroid genus; but Kirkaldy referred to it a second species (*aequalior*) which evidently does not belong in it and

[6] Berl. Ent. Zeit. 6 (1862) 303.

[7] Ofv. Vet. Ak. Forh. 11 (1854) 251.

[8] Ofv. Vet. Ak. Forh. 34 (1887).

[9] Haw. Sugar Planters' Exp. Sta. Bull. 12 (1913) 10.

Schmidt, without having seen this very insufficiently described species, bases on it his genus *Polytrichophyes*.[10] This also may be *Hindola*. Later Schmidt,[11] who had not seen *Hindola*, described *Modiglianella* from Sumatra and not one of the supposedly diagnostic characters given but falls within the limits of specific characters in *Hindola*.

Schumacher [12] describes a genus *Taihorina*, based upon *T. geisha* from Formosa. The numerous characters mentioned in the generic descriptions all fall within the range of specific characters in *Hindola*, which was evidently unknown to this author. The species, however, appears to be a distinct one. Finally, Distant, who knew *Hindola viridicans* and had described several other species of the genus, described a new genus, *Quinquatrus*,[13] based upon *Q. dohertyi* from Tenasserim and another, called *Xenaias*, based upon *X. notandus* from the Nilgiris. His figures present nothing distinctive, and it is certain that no diagnostic characters are given. These, therefore, must also be referred questionably to synonymy until the details of structure, especially venation, are made known.

We were fortunately able to collect in Singapore a series of the type species of *Hindola* and with this as a starting point have been able to make illuminating comparisons with Australian, Bornean, and Philippine species. In this study it was found that some of the characters previously used as of generic significance were not even of specific value, the degree of obliquity of the head sometimes differing considerably in the two sexes. Also there are sometimes considerable sexual differences in sculpture, as has been indicated in the description of the scutellum of *Serreia*, as well as in color. The basal spur of the hind tarsi varies greatly in size and is often nearly or quite obsolete, and may be present on one side and absent on the other in a single specimen. In describing the genus, Stål refers to the transversely depressed crown with fore and hind borders raised. Some of the Australian species show this equally well, but this has all gradations to a crown that is obliquely plane and with only the hind margin raised or with neither margin elevated. In all we find the same general pattern of venation in the perfectly plane, subhyaline, rarely colored tegmina, the

[10] Stett. Ent. Zeit. 73 (1912) 173.
[11] Stett. Ent. Zeit. 79 (1918) 366.
[12] Mitt. Zool. Mus. Berlin 8 (1915) 84.
[13] Fauna Brit. Ind. Rhynch 6 (1916) 197.

veins usually decolored and inconspicuous except by transmitted light. The scutellum is evenly convex and usually very lightly punctuate or wrinkled. In the type species the pronotum is thickly, obliquely punctate-rugose and in other species there are variable admixtures of punctures and rugæ. Even those that have a proponderance of punctures will be found usually to have well-defined wrinkles laterally. Genera cannot be based on these differences. There is the greatest need, for a proper understanding of this group and its various species, to have rearings made of good series of both males and females from the curious calcareous tubes which the nymphs inhabit, and it is hoped that these remarkable insects will receive the active attention of all Indo-Malayan and Australian entomologists. The tubes in this group are much smaller than are those of *Machærota* and are more easily overlooked, but they are abundant in many districts, as the collection of mature forms shows. The correct association of the sexes in each case will help a great deal toward the proper elucidation of the species and also of the genera.

HINDOLA VIRIDICANS Stål.

Anatomical details of this common Singapore species, the type of the genus, are given in figs. 16 to 21. There is an appreciable difference in the length of the crown and in its obliquity in the two sexes. While the head (fig. 16) is in this species distinctly narrower than the pronotum, it varies to nearly as wide in some other species. The description of Stål gives clearly the general characters of the species. The extent of reddish suffusion on crown, pronotum, and scutellum is very variable.

HINDOLA LUZONENSIS sp. nov.

Male.—Length to end of closed tegmina, 6.25 millimeters; width of head, 2; of pronotum, 2.25; length of tegmen, 5.25; width at end of clavus, 2.

Color olive green, crown reddish stramineous; face piceous, a median oval frontal dot on line of antennal insertions; clypeus sordid yellowish. Mid and fore legs pale brownish, hind legs sordid yellowish. Inner half of clavus olive green, outer half and entire corium evenly pale chocolate brown.

Frons gently convex, slightly swollen basally, microscopically transversely lacunose, lateral raised arcs obsolete, entire genæ and loræ thickly finely rugose. Crown (fig. 22) with very

uneven surface, rather strongly depressed along frontal suture, on lateral area, and on disk of superior portion of front; hind margin sharply raised but anterior margin not raised; all parts of surface of crown with very coarse, obtuse, irregular wrinkles; in vertical view (fig. 23) the crown is rather strongly angulate anteriorly, the interocellar distance is actually subequal to the length of the true vertex (not apparent on the curved surface as seen from above). Length of pronotum two-thirds of its width, anteriorly obtusely subangulate, posteriorly very obtuse angulately emarginate, its surface rather strongly transversely punctate wrinkled. Scutellum not quite as long as pronotum on median line, its surface very slightly convex and finely transversely wrinkled. Tegmina densely, coarsely, very uniformly punctate throughout, resembling in this character some of the Australian species.

A single fully mature male taken at Baguio, Benguet Subprovince, northern Luzon (*Baker*). Another male specimen, juvenile and pale in color throughout, but with the same structural characters, and evidently of this species, was taken at Imugan, Nueva Vizcaya Province, not a great distance from Baguio.

One of the most deeply colored of this group, and in this resembling certain *Chaetophyes*, but in form and structure a typical *Hindola*.

HINDOLA FULVA sp. nov.

Female.—Length to end of tegmina, 4.75 millimeters; width of head, 2; length of tegmen, 3.75; width at end of clavus, 1.75.

Color of crown, pronotum, and scutellum deep uniform fulvous; a narrow transverse arcuate stripe before apical margin of pronotum pale yellowish; all below with pleuræ, abdomen, and legs pale yellowish. Tegmina hyaline; basal half of clavus somewhat thickened callose and lemon yellow; clavus apically with a pale brownish commissural spot; numerous very scattered brownish dots occur on the veins, most numerous near and along costal margin, the two middle apical veins with larger brownish spots.

Frons medially somewhat flattened, remainder gently convex; surface of front, genæ and loræ minutely, thickly, obscurely rugose. Entire surface of crown, pronotum, and scutellum thickly, deeply, but very minutely punctate-rugose, giving these surfaces a velvety appearance. Crown (fig. 26) somewhat depressed, most strongly in ocellocular area, somewhat concave in

profile, though the general plane is oblique in general line of slope of anterior part of pronotum; interocellar distance slightly greater than length of true vertex; superior face of front sharp margined around its strong obtuse angulate apex, its surface with a blunt thick median wrinkle and its middle crossed transversely by a similar but arcuate wrinkle. Head and pronotum proportionally very broad, the former slightly the narrower. Pronotum with a strong median carina on anterior half, its length but little more than half the width. The posterolateral margins rather strongly sinuate. Scutellum considerably longer than pronotum, its surface gently evenly convex, slightly depressed before apex. Subbasal hind tibial spur stronger than usual but not half the size of subapical. Venation of tegmen and wing (figs. 27 and 28) typically that of *Hindola*, but corial appendix somewhat longer.

Male.—Length to end of tegmen, 4.5 millimeters; width of head, 1.75; length of tegmen, 3.5; width at end of clavus, 1.5. Closely similar in all respects to the female.

This species is not uncommon in Singapore and it will be of the highest interest and importance to discover its tubes and to compare them with those of *Hindola viridicans*.

It was this and the following species that led me to doubt the feasibility or wisdom of attempting to divide the *Hindola* group into several genera on our present knowledge. These two species have longer crown, broader head and pronotum, and a more compact squat appearance than has the type of *Hindola*. They also possess brown-dotted tegmina. The sculpture is as distinctive in its way as is that of *Parahindola*, but in another direction.

The next species, *nitida*, very close to *fulva* in form and structure, has sculpturation of an entirely different type. On close comparison of all of the above characters that might be used for generic distinction they were found to exist in all degrees in the various species, and in all combinations. The description of the following species will illustrate this point.

HINDOLA NITIDA sp. nov.

Female.—Length to end of tegmina, 4.75 millimeters; width of head, 2; length of tegmen, 3.75; width at end of clavus, 2.

Color olive green, usually with an evanescent reddish suffusion invading more or less of crown, pronotum, and scutellum. Sternum and lower half of face piceous, shading on face into sordid yellowish on upper half. All femora, except extreme bases and

apices, piceous, remainder of legs sordid yellowish. Tibial spurs as in *H. fulva*. Tegmina hyaline, extreme base and a narrow stripe extending from claval commissure before its apex to center of corium, pale brown; darker brownish dots occur on the veins as shown in fig. 31. Abdomen dark colored with the first tergite laterally conspicuously paler.

Frons very gently convex, smooth and shining, with slight, very indistinct, microscopical remnants of sculpturing; surface of clypeus, loræ and genæ thickly coarsely rugose. Crown (fig. 30) very similar to that of *H. fulva* but hind margin strongly raised, the superior frontal surface shorter for its breadth, with no transverse wrinkle, the median fold broader and more obscure. The pronotum (fig. 29) like that of *H. fulva* but median carina reduced to a remnant near anterior border, the surface shining, the sculpturing a delicate shallow transverse wrinkling with scattering punctures; this type of sculpturation is still more indistinct on the scutellum. Venation (fig. 31) closely similar to that of *H. fulva*.

Male.—Length to end of tegmina, 4 millimeters; width of head, 1.75; length of tegmen, 3.25; width at end of clavus, 1.5.

Very similar in all respects to the female, but in these specimens with the scutellum very strongly reddened.

This species was found to be not uncommon at Sandakan, British North Borneo (*Baker*). Differs from all other species in the short transverse brown stripe on clavus and inner half of corium.

Genus CHAETOPHYES Schmidt

This seems to represent a well-distinguished generic group. The body is very thick and stout and more "humpbacked" than in *Hindola*. The surface of tegmina is farther from uneven than in any *Hindola* and the width is greater in proportion to the length. The basal frontal suture is nearer to the ocelli (these being nearer to it than to base of head) a condition not noted in any *Hindola*. The interocellar distance is also proportionally less than the ocellocular. Form of crown, pronotum, and scutellum are indicated in figs. 32 and 33. The venation (figs. 34 and 35) is essentially that of *Hindola*. The cross vein in middle anteapical cell in fig. 34 is abnormal.

Several Walkerian species are to be referred here, and doubtless some of Spangberg's "*Hindolas*" belong here. One of the most marked characters of the genus lies in the strong dimor-

phism of the sexes. Schmidt described *Chaetophyes bicolor*[14] from female specimens, while the smaller black males of the same species he described as *C. unicolor*. I have large series of these taken standing together on the same plant, the *bicolor* form all females, and the *unicolor* form all males. This species has apparently been redescribed by Hacker as *Polychætophyes perkinsi*.[15] The acute clavus of the latter apparently excludes it from *Polychætophyes*. Walker seems, likewise, to have separated sexes of this group as distinct species.

Genus HINDOLOIDES Distant

Distant describes this genus[16] with the species *H. indicans* from Calcutta, as a relative of *Hindola*, both of which he places among ptyeline cercopids. He does not remark its strong resemblance to *Clastoptera* nor the remarkable fact that the clavus is broadly truncate apically as in that genus. He speaks of three "apical cells" in corium, but apical cells are entirely absent (fig. 38), the cells present being the anteapicals of *Hindola*, the space of the apicals being occupied by the enormously developed corial appendix. The wing venation (fig. 39) is typically machærotid. Outlines of crown, pronotum, and scutellum are given in figs. 36 and 37. The figures are prepared from Calcutta specimens.

Kirkaldy gave a very imperfect description of *Polychætophyes* and did not figure the venation, but he apparently noted and appreciated the importance of the extraordinary structure of the clavus. Recently Hacker[17] described a species, *appendiculata*, his figure showing the same remarkable corial appendix that occurs in *Hindoloides*, but which Kirkaldy does not mention for *Polychætophyes*. In Hacker's figure it appears that true apical cells are present in the corium, and this may distinguish it from *Hindoloides*. Kirkaldy may have overlooked the broad appendix which at rest is folded closely under the apex of abdomen. This emphasizes the great need of clear figures illustrating *Polychætophyes serpulida* Kirkaldy, the type of the genus.

[14] Stett. Ent. Zeit. 79 (1918) 367.
[15] Mem. Queensl. Mus. 8 (1926) 246, fig. 6.
[16] Ann. & Mag. Nat. Hist. 16 (1915) 506.
[17] Mem. Queensl. Mus. 8[3] (1926) 247, fig. 1.

It is hoped that Indian entomologists will soon locate the calcareous tubes of *Hindoloides* and compare them with those of *Polychætophyes serpulida*, figured by both Hacker and Kirkaldy.

Hacker [18] gives a very interesting account of the emergence of two of these remarkable tube-dwelling machærotids. His determination of the species, however, seems questionable as to *Polychætophyes*, the lower insect in his fig. 4 apparently being not of that genus at all, since it has an acute clavus. At any rate, *P. serpulida* of Hacker's figure and his later *P. appendiculata* have no near generic relationship. If Hacker's 1922 figure really represents *Polychætophyes*, then it seems possible that we are wrongly interpreting Kirkaldy's description of the clavus, in which case *Chætophyes* will be synonymous, and *Hindoloides* will stand quite by itself.

Some time after this paper was submitted for publication, Mr. W. E. China very kindly sent to me the accompanying illuminating figures (Plate 4) made directly from the types of *Quinquatrus* and *Xenaias*. These figures fully confirm my assignment of these two genera to *Hindola*. Distant's description of *Xenaias* [19] is entirely made up of generalities applying to any member of this group. It is evident from Mr. China's figure that the minute basal spine was overlooked by Distant, since he described the posterior tibiæ as having only one spine; and this is a matter of no importance in this group, since the very weak basal spine may be present or absent in the same species. Mr. China remarks (in litt.) of *Xenaias notandus* Distant:

> Pronotum strongly reticulately rugose, the reticulations fine and almost obsolete along the anterior margin and on vertex. Basal half of scutellum slightly concave, and rugose. Tegmina somewhat rugosely reticulate, extending about one-third their length beyond tip of abdomen; venation obscure, and variable in details.

To these points may be added the elongate form of tegmina with the very long anteapical cells, elongate third apical cell of wing, and wider vertex with slightly more angulate apex. All of these characters well mark the species *notandus*, but none of them can serve as generic distinctions since they all

[18] Mèm. Queensl. Mus. 7 [4] (1922) 282, 480, 2 pls.
[19] Fauna Brit. Ind. Rhynch. 6 (1916) 198.

fall within the limits of *Hindola* species. I have already shown the occurrence of great variety in sculpture and form in various combinations in *Hindola*.

Quinquatrus (Plate 4, fig. 1) is just as clearly *Hindola*, the general lineaments, like those of *Xenaias*, being unmistakably those of *Hindola*. Of *Q. dohertyi* Mr. China (in litt.) says:

> Anterior two-thirds of pronotum obliquely rugosely wrinkled on each side of middle line; the posterior third almost smooth. Anterior margin and vertex much more strongly and irregularly rugose. Tegmen obscurely, coarsely punctate: veins of tegmen obscure, somewhat variable in detail.

Distant described the same pronotal sculpture as "thickly finely punctate," and punctures will doubtless be evident among the rugose wrinkles in certain lights, a character of great variety in *Hindola*. Distant's statement "pronotum about twice as broad as centrally long," is entirely incorrect, even according to his own figure. His statement "tegmina with three apical cells" is also incorrect; but the outer apical cell in this group is often indistinct. There is no character mentioned in connection with this species that can possibly be used for generic distinction and it must therefore be left in *Hindola*, in the neighborhood of *H. fulva* and *H. nitida*, described above, which it resembles.

The cases of *Xenaias* and *Quinquatrus* clearly illustrate the utter insufficiency which characterizes the descriptions of Distant's genera of Cercopioidea, as well as of Jassoidea. Such anatomical figures as those presented by Mr. China would make it readily possible to understand all of them and to place them properly among other described genera. As it is, they are an almost insuperable obstacle to the formation of any usable classification of Indian and Malayan forms. Mr. China's magnanimous willingness to supply figures, in this as well as other cases of the sort, is very highly appreciated and is of the greatest constructive utility.

Since I wrote the above, my atttention has been called to the fact that the genus *Hindoloides* has been redescribed by Haupt [20] under the name "Weigoldella."

[20] Deutsch. Ent. Zeitsch. (1923) 299.

ILLUSTRATIONS

PLATE 1

FIGS. 1 to 3. *Conmachærota attenuata* sp. nov.; *1*, profile of head, pronotum, and scutellum; *2*, crown, vertical to its plane; *3*, dorsum of body of scutellum.

4 to 6. *Conmachærota mindanaensis* sp. nov.; *4*, profile of head, pronotum, and scutellum; *5*, crown, vertical to its plane; *6*, dorsum of body of scutellum.

7 to 12. *Serreia notabilis* sp. nov.; *7*, crown, vertical to its plane; *8*, pronotum; *9*, profile of head, pronotum, and scutellum; *10*, sublateral view of head; *11*, tegmen; *12*, wing.

PLATE 2

FIGS. 13 to 15. *Parahindola borneensis* sp. nov.; *13*, dorsum of head, pronotum, and scutellum; *14*, profile view of head, pronotum, and scutellum; *15*, tegmen.

16 to 21 *Hindola viridicans* Stål; *16*, dorsum of head, pronotum, and scutellum; *17*, crown, vertical to its plane; *18*, profile view of head and pronotum; *19*, face; *20*, tegmen; *21*, wing.

22 to 24. *Hindola luzonensis* sp. nov.; *22*, dorsum of head, pronotum, and scutellum; *23*, crown, vertical to its plane; *24*, tegmen.

PLATE 3

FIGS. 25 to 28. *Hindola fulva* sp. nov.; *25*, dorsum of head, pronotum, and scutellum; *26*, crown, vertical to its plane; *27*, tegmen; *28*, wing.

29 to 31. *Hindola nitida* sp. nov.; *29*, dorsum of head, pronotum, and scutellum; *30*, crown, vertical to its plane; *31*, tegmen.

32 to 35. *Chaetophyes bicolor* Schmidt; *32*, dorsum of head, pronotum, and scutellum; *33*, crown, vertical to its plane; *34*, tegmen; *35*, wing.

36 to 39. *Hindoloides indicus* Distant; *36*, dorsum of head, pronotum, and scutellum; *37*, crown, vertical to its plane; *38*, tegmen; *39*, wing.

PLATE 4

FIG. 1. *Quinquatrus dohertyi* Distant, female. (Drawings by W. E. China, from the type specimen in the British Museum.)

2. *Xenaias notandus* Distant. (Drawings by W. E. China, from the type specimen in the British Museum.)

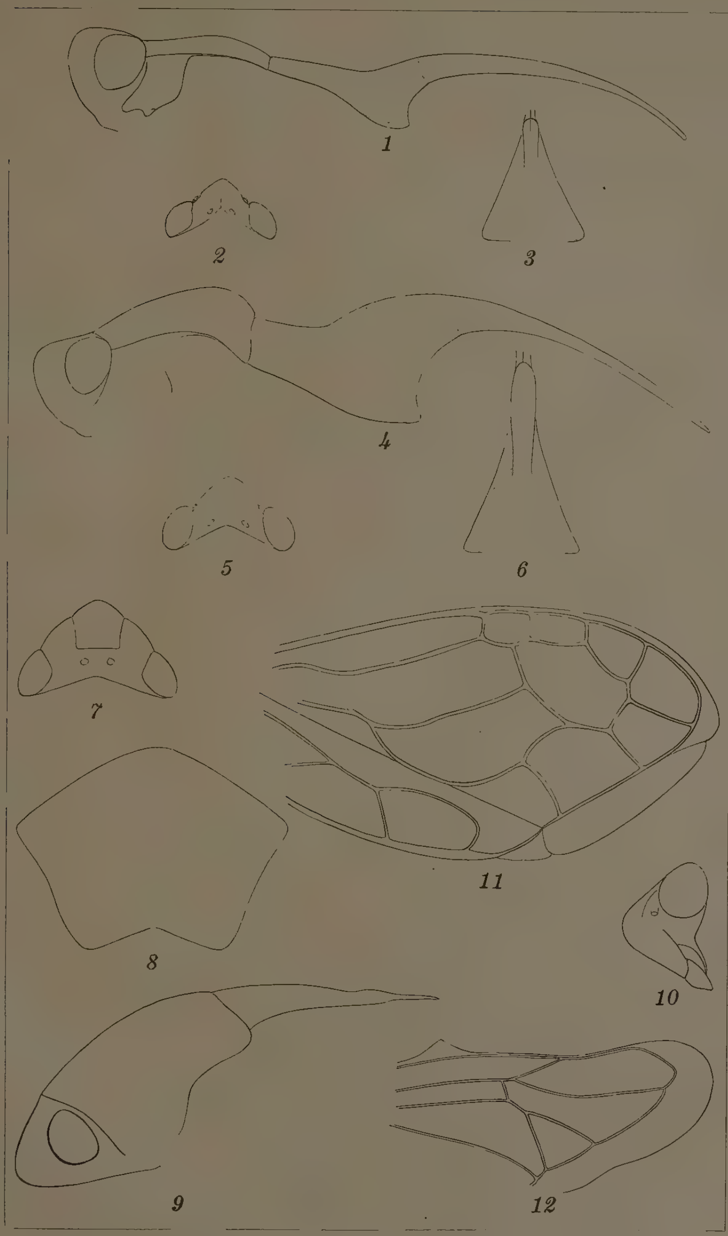


PLATE 1.

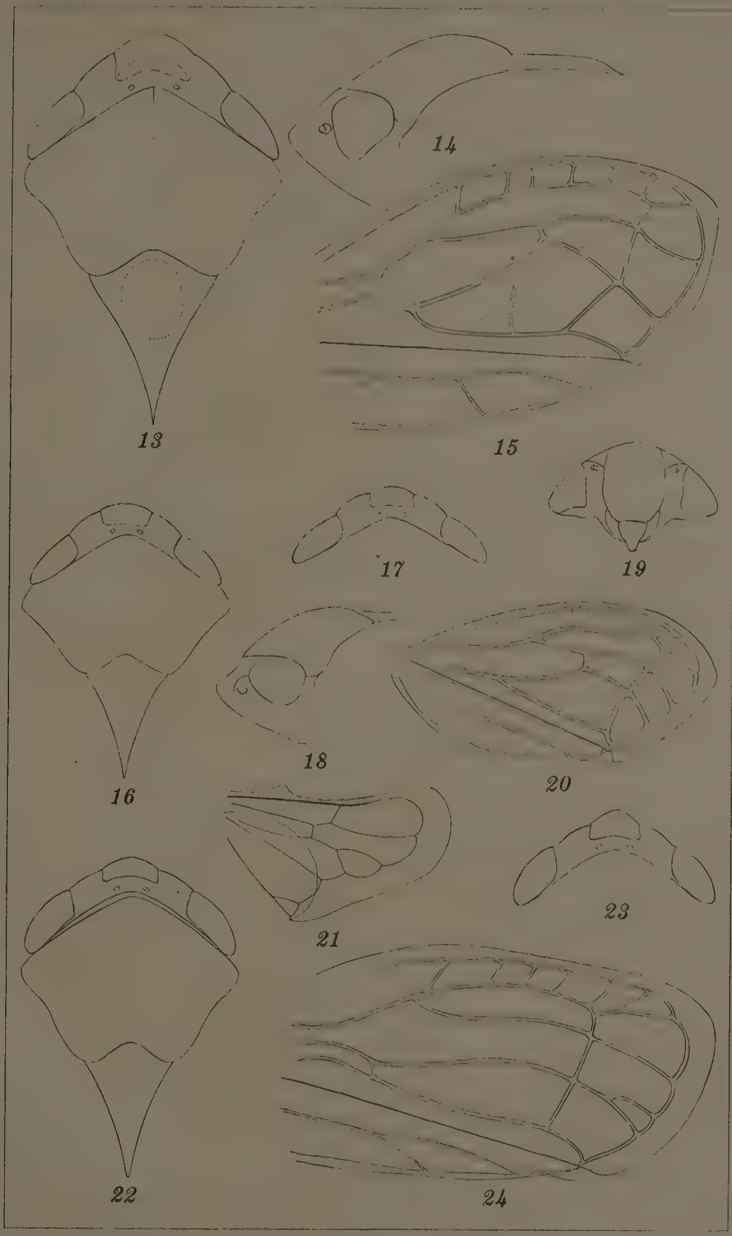
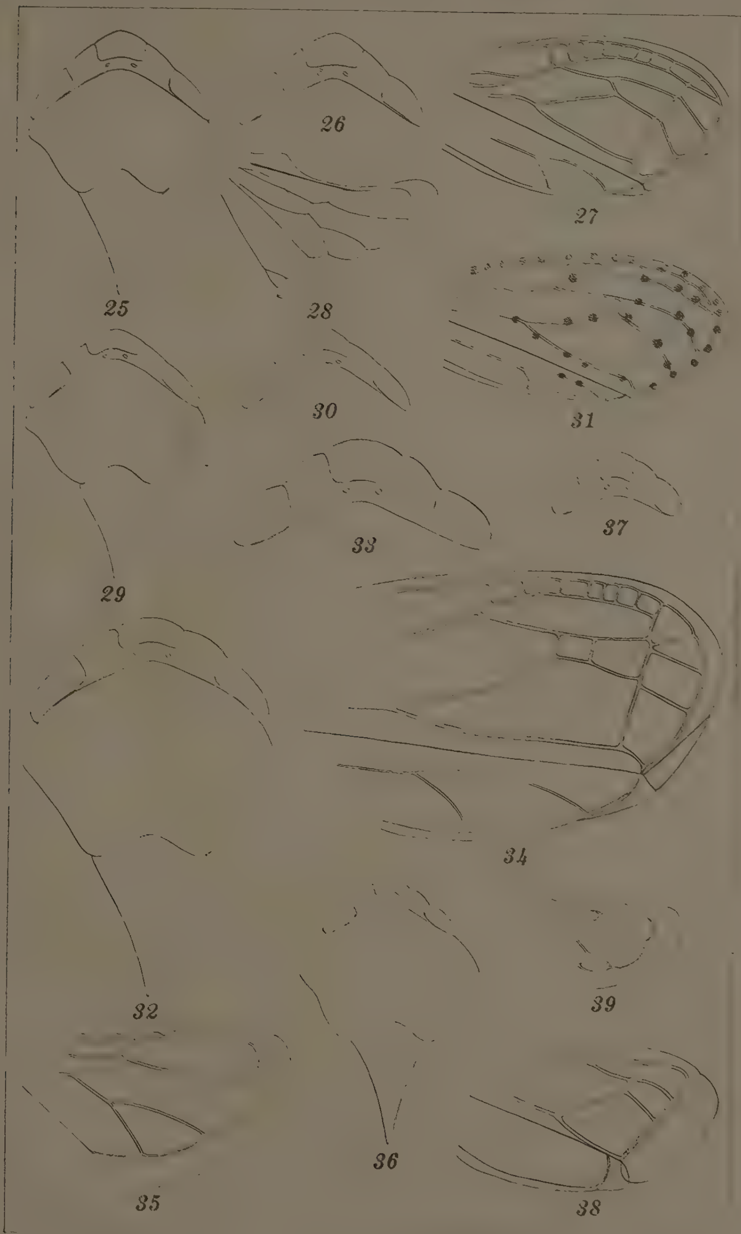


PLATE 2.



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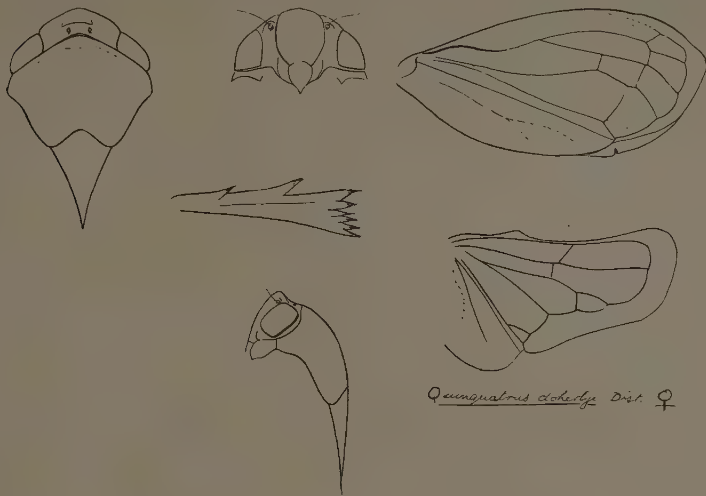

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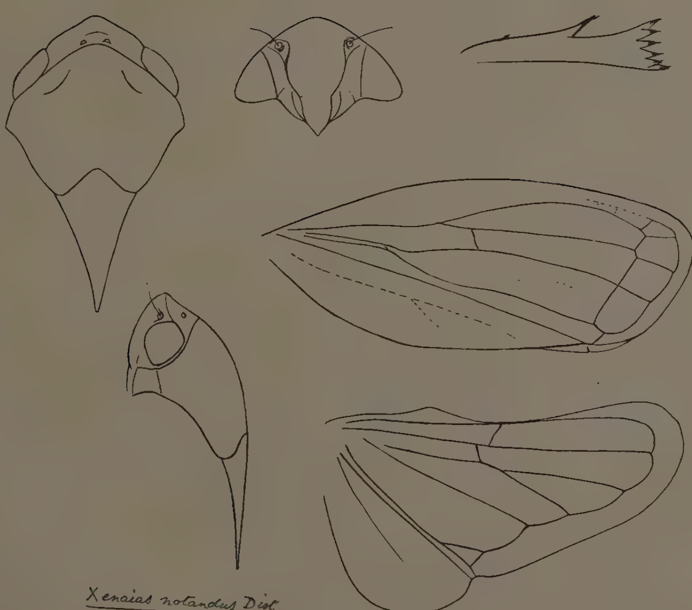

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PLATE 4.

UEBER EINIGE TOMASPIDINÆ (RHYNCHOTA, HOMOPTERA) VON DEN PHILIPPINEN

Von A. JACOBI

Dresden, Saxony, Germany

Mehrere Cercopiden von den Philippinen, um deren Bestimmung mich Herr Baker ersuchte, erwiesen sich als neue Arten, deren Bekanntmachung in dem Philippine Journal of Science er freundlichst vermittelte; die Typen sind im Museum für Tierkunde in Dresden aufbewahrt. Näher eingegangen wird dabei auf die Gattung *Mioscarta* Bredd., die im Archipel der Philippinen einen ziemlichen Artenreichtum entwickelt zu haben scheint. Diese Gattung hat auffallend lange und noch mit langen Anhängseln versehene Subgenitalplatten oder Gonapophysen, aber diese scheinen nicht zu spezifischen Unterschieden ausgebildet zu sein, wenigstens nicht in diesem Faunengebiete, weshalb ich sie in den Artbeschreibungen unerwähnt lasse. Auch die schwarze Zeichnung der Vorderbeine ist bei den dortigen Arten von einer Einförmigkeit, die zu der sonstigen Verschiedenheit der Färbung im Gegensatze steht.

Die Masse sind einschliesslich der angelegten Deckflügel genommen.

MIOSCARTA FERRUGINEA (Walker).

Habitat, Samar (*Baker*); 2 Weiber.

MIOSCARTA SEMPERI Jacobi.

Diese Art, welche Lallemand auf meine Veranlassung hin als Synonym zu der vorigen gestellt hatte, ist doch spezifisch verschieden durch die scharfe Abtrennung des orangegelben Basalteils von dem distalen dunkeln durch eine schwarze Linie und durch die Scheitelzeichnung. Es sind nämlich nur zwei kleine schwarze Pünktchen auf der Quernaht vor den Ocellen vorhanden, während die Gegend zwischen Ocellen und Augen einfarbig ist wie der ganze übrige Scheitel. *Mioscarta ferruginea* hat dagegen immer diesen Zwischenraum der Sehorgane schwarz ausgefüllt und das Rosenrot in der Apikalhälfte der Deckflügel ist weiter ausgedehnt. *Mioscarta rubens* E. Schmidt hat wieder den

Scheitel einfarbig und das Rosenrot in der Apikalhäfte der Deckflügel ist weiter ausgedehnt.

MIOSCARTA BASILANA sp. nov.

Kopf und Brustteil scherbengelb; zwei Pünktchen in den Hinterwinkeln des Stirnscheitelteils, Fühler, Seiten der Stirn in der Basalhälfte und bis zu den Augen und ein sehr feiner, vom Kopf fast verdeckter Vordersaum des Pronotums schwarz. Beine wie sonst gezeichnet. Deckflügel im Basalviertel scherbengelb, im übrigen schwarzbraun, an der Grenze gegen den hellen Basalteil zu schwarz verdunkelt, in der Apikalhälfte aufgehellt und mit einem breiten trübroten Costalsaum, der sich bis zur Apikalspitze ausdehnt; die ganze Fläche der Deckflügel mit dicht anliegendem gelben Filz bedeckt. Hinterleib in der Basalhälfte scherbengelb, apikad schwarz. Im Köperbau sind keine Abweichungen die beständig wären.

Länge, 7 Millimeter.

Habitat, Insel Basilan (*Baker*); 4 Weiber.

MIOSCARTA FLAVOBASALIS sp. nov.

Kopf, Brustabschnitt und Beine ockergelb; Augen braun und scherbengelb marmoriert; neben den Augen eine mehr oder weniger dunkle Trübung. Hinterleib an der Basis und mehr oder weniger in der Mitte der Ober- und Unterseite ockergelb, sonst pechschwarz. Deckflügel im Basalviertel ockergelb, sonst schwarz, der netzadrige Teil aussen mit einem schmalen, rotbraunen Aussensaume. Flügel dunkel rauchgrau, nach der Basis hin noch dunkler, diese selber ockergelb. Im Bau nicht merklich von den übrigen Arten, insbesondre *M. ferruginea*, verschieden.

Länge, 10 bis 11 Millimeter.

Habitat, Insel Samar (*Baker*); 1 Mann und 1 Weib.

POECILOTERPA ATRA sp. nov.

Dunkel pechbraun, im Apikalteil der Deckflügel etwas aufgehellt. Seiten der Stirn, Schnabel und Beine heller braun, gelegentlich ins rötliche ziehend. Strukturell in jeder Beziehung *P. latipennis* E. Schmidt gleich, bis auf das schärfer herausgepresste apikale Geäder der Deckflügel; auch ist diese Art etwas kleiner.

Länge, 4 Millimeter.

Habitat, Insel Polillo (*Böttcher*); 2 Weiber.

Nach dem Aderverlauf in den Flügeln schliesst sich die Gattung *Poeciloterpa* Stål sehr nahe an *Mioscarta* Bredd. an, insofern ihr ebenfalls die Querader zwischen Subcosta und Radius$_1$ fehlt, aber die Subcosta ist in der Gegend, wo sie sonst von der Quer-

ader getroffen wird, noch viel stärker nach innen ausgeschweift, sodass sie dort zweimal fast im rechten Winkel gebogen ist.

EOSCARTA BOREALIS Distant.

Habitat, Mindanao, Davao (*Micholitz*); 1 Weib.

Das einzige Exemplar ist von solchen aus Assam und Laos nicht zu unterscheiden, wobei an die Möglichkeit der Einschleppung in jüngster Zeit gedacht werden darf.

Zwischen *E. laoensis* E. Schmidt und *E. liternoides* Bredd. scheint kein fester Unterschied zu bestehen, da auch die letztere Art in den Diskal- und Apikalzellen dunkle Flecke von verschieden starker Tönung zu haben pflegt.

EOSCARTA COLONA sp. nov.

Schmutzig erdbraun, die Vorderfassette der Stirn blass ockergelb, die Stirnseiten schwärzlich; Hinterhälfte des Pronotums, Gegend des Clavus und der Apikalteil der Deckflügel dunkelbraun, das Geäder im Apikalteile wieder hell herausgehoben. Hinterleib auf den Sterniten mit Schwarzen Querbinden. Vorderrand des Kopfes ziemlich stark halbmondförmig gebogen, woraus der Stirn-Scheitelteil wieder etwas hervorragt. Stirn mit groben Seitenfurchen, der Längseindruck bleibt um ein Drittel seiner Länge unter der Basis. Costalrand wenig gebogen, das Apikalgeäder tritt wenig heraus und ist unregelmässig genetzt. Am nächsten wohl mit *E. ferruginea* Distant verwandt.

Länge, 8 bis 9.5 Millimeter.

Habitat, Ostindien, Pondicherry; 1 Mann und 1 Weib.

COSMOSCARTA LATERALIS sp. nov.

Kopf, Pronotum, Schildchen, Pro- und Mesostethium, Deckflügel schokoladenbraun, bisweilen an der Stirn rötlich aufgehellt; vordere Seitenränder des Pronotums und die Zeichnung der Deckflügel rötlich ockergelb; letztere besteht aus drei Flecken an der Basis, drei mittleren in Corium und Clavus und einer gewinkelten Querbinde vor dem Apikalteile. Ocellen bernstein- bis rötlichgelb. Flügel hell rauchgrau, die Adern an der Basis hellrot. Beine dunkel ziegelrot, beim Mann (1 Exemplar) die Vorder- und Mittelbeine dunkelbraun. Hinterleib gelbrot bis ziegelrot, in schwankender Ausdehnung geschwärzt.

Ocellen unter sich und von den Augen gleichweit entfernt. Pronotum in der Mitte stark gewölbt, vordere und hintere Seitenränder sanft gebogen. Basaldorn der Hinterschienen winzig klein.

Länge, 12.5 bis 15 Millimeter.

Habitat, Insel Samar (*Baker*); 1 Mann und 1 Weib.

FOUR NEW CHALCID FLIES FROM THE PHILIPPINES

By A. A. Girault

Of the Department of Agriculture, Brisbane, Queensland

The following chalcid flies were received from and collected by Prof. C. F. Baker. The types are in the Queensland Museum. The generic position of *Macrodontomerus silvifilia* sp. nov. is uncertain, but its description gives all essentials necessary.

EUPELMINIÆ

EUPELMINI

CALOSOTA SPLENDIDA sp. nov.

Ovipositor stylate, compressed, nearly half of rest of abdomen, exceeding any segment; eyes naked; scutellum margined laterad. Antennæ at end of eyes, scrobes deep, joining halfway up and attaining median ocellus, a curved, narrow sulcus from each antenna to end of head. Furrows half complete, faint sutures well separated, nearly straight lines from cephalad and not far from median line. Postmarginal over twice the well-developed stigmal. Large, rather slender.

Brilliant green, scape except apex and legs except coxæ red; apex tegula dark red; abdomen above and a large conic marking from cephalic end of scutum (green along the furrows) to near center of scutellum (blunt at its apex) coppery; forewing lightly infuscated and with a narrow middle line of dark fuscous from apex to under base of bend of submarginal.

Prothorax shining, some hairs on each side cephalad; face and lower cheeks umbilicately punctate, parapsides more coarsely and densely so; rest of mesonotum finely punctate and reticulate, densely pilose; spiracle large, oval; upper occiput densely pilose; mesopleurum naked, reticulated, this sculpture gradually changing to punctuation cephalad. Funicle 1 twice longer than wide, equal to 8, a bit shorter than pedicel; 2 elongate, thrice 1; the rest gradually shortening, club equal 5.

A female, Cuernos Mountains, Occidental Negros, Negros. Not typical for the genus.

TRYDYMINÆ

METASTENINI

METASTENOIDES FERUS sp. nov.

Clypeus strongly bidentate at meson; less robust than in the genotype, propodeum noncarinate, with an obscure cross ridge before middle; segment 7 longest, then 2 and 6, the three united half of surface; 3 to 5 equal, each not two-thirds of 2.—

Aëneous, wings clear, coxæ, femora concolorous, tibiæ 1 and 2 save apex, 3 at proximal one-half, dark brown, rest of tibiæ, tarsus 3 and 1 of tarsi 1 and 2, white. Scape, pedicel red brown, rest of antennæ black, a bit suffused reddish. Lateral ocelli closer to median than to eye.

Scape twice the club; funicle 1 two and a half times longer than wide, 2 and 3 twice longer than wide, 5 one-third longer than wide, equal pedicel.

Tegulæ yellow; postmarginal nearly twice the elongate stigmal. Ciliation to about middle bend of submarginal, then after a short space more loosely to base on more than cephalic half.

A female, Cuernos Mountains, Occidental Negros, Negros.

CLEONYMINÆ

Genus THAUMASURELLOIDES novum

Differs from typical *Thaumasura* in having 13-jointed antennæ, club 3-jointed, ring joint large; abdomen rounded above and with only four segments between propodeum and stylate part, the first (or 2) very short, the fourth (or 5) longest and with a median carina; 6 and 7 stylate, 6 longest segment and 7 next, ovipositor extruded beyond them for over the length of 6 and 7; stylus and ovipositor over twice the rest of body, straight. Fore and hind femora slender, unarmed, large.

Type, *Thaumasurelloides silvae* sp. nov.

THAUMASURELLOIDES SILVAE sp. nov.

Dark blue, wings subhyaline, base of scape, tibiæ except 3 at basal one-half more or less, femora except 1 and 3 more or less, tarsi, tegulæ dark red. Densely punctate including propodeum and abdomen, finest on pronotum and vertex, almost reticulation on occiput, coarser on thorax than on abdomen, nearly reticulation on stylate segments which are carinate at meson above. Ciliation to base of wing except caudad. Funicle 1 somewhat longer than wide, 2 longest, two and one-half times longer than wide, 3 twice longer than wide, 8 quadrate. Club 1 half that region. Hind tibial spurs short, subequal.

Propodeum with short, strong median carina, spiracle large, curved, no sulcus. Segment 5 of abdomen longer than wide. Lateral ocellus a bit closer to median than to eye but farther apart from each other than to eye. Eyes hairy, upper thorax pilose. Pedicel not elongate, distinctly shorter than funicle 2; club short but longer than distal funicle.

A female, Mount Maquiling, Luzon (*Baker*), type.

Cotype, a half smaller female, Cuernos Mountains, Occidental Negros, Negros.

This remarkable form belongs to a group difficult to classify, since it has been divided upon a variable amount of swelling in the femora, and recent studies lead me to believe that some duplication of genera has taken place.

TORYMINÆ

MONODONTOMERINI

MACRODONTOMERUS SILVIFILIA sp. nov.

Antennæ 13-jointed, one ring joint; hind femur beneath armed with a distinct, rather large, acute pale tooth; scutellum with distinct cross suture. Hind femur excised distad of tooth. Maxillary 4-labial, palpi 3-jointed. Abdomen compressed, the ovipositor slightly exceeding it. Propodeum noncarinate, at base with four large foveæ, the two at meson very large; a large slitlike spiracle from which a wide sulcus runs. Postmarginal over twice the short, curved stigmal.

Brilliant green, wings clear. Knees, tibiæ, tarsi, scape white; a little over distal half of the clavate tibiæ 3 black. Pedicel brownish.

Scutellum umbilicately punctate, glabrous beyond cross suture, rimmed at apex. Scutum and parapsides with numerous smaller punctures and cross striation, punctures denser and larger on lateral parapside. Axillæ subglabrous at base. Head pilose and with pin punctures, rougher on vertex and with cross rugæ. Upper occiput margined. Lateral ocellus slightly closer to median than to eye. Upper thorax and vertex pilose.

Funicle 1 a half longer than wide, 7 slightly longer than wide, much exceeding the cup-shaped pedicel. Ring joint cup-shaped. Jaws 3-dentate, 1 and 2 acute, 3 wide.

Two females, Cuernos Mountains, Occidental Negros, Negros (*Baker*).

INTRAHEPATIC ADMINISTRATION OF DRUGS

By F. A. Fidelino and P. A. Pañgan

Of the Department of Pharmacology, College of Medicine
University of the Philippines, Manila

SIX PLATES

INTRODUCTION

In 1923 Waddell[1] called attention to the intrahepatic route as a convenient method of administering drugs to small animals such as turtles, rats, and frogs. He claimed that the dosage and the time of absorption were more uniform under this method than with application direct to the organs (dropping the solution on them) or with subcutaneous or gastrointestinal administration. The quick onset of effect was attributed by him to rapid absorption.

We also have obtained quick action from intrahepatic administration, but this was not always due to absorption and the effects of the drugs were not uniform. The response of a frog's heart to stimulant drugs was capricious. Moreover, we have obtained effect from plain Ringer solution that was sometimes indistinguishable from that from caffeine or epinephrine. The main feature of our work, which is based on more than one hundred fifty experiments, is reported in this paper.

Method.—The plan of the experiment was simple. It consisted simply of injecting drug and control solutions into the liver substance and recording the cardiac contractions. Frogs (*Rana vittigera*) were used in the experiments. The animal was pithed; the liver and the heart were exposed by a median ventral incision. The pericardium was opened and the apex of the heart was connected in the usual manner with a light lever. The cardiac contractions were recorded on a slowly revolving drum. A tuberculin syringe was filled with the solution and was so arranged that the point of the needle was deep in the liver substance and injection could be made without disturbing the record of the kymograph. Both of us were able to make such

[1] Journn. Phamacol. & Exp. Therap. 21 (1923) 225.

injections after a little practice. In order to avoid distention of the auricles the volume of the solution should be small and it should be injected slowly.

Mechanism of absorption.—The quick onset of systemic effect from intrahepatic injection has been attributed to rapid absorption. We have frequently observed that injections producing such effect also caused slight but definite distention of the auricles. With dead frogs of medium size 3 minims of a solution slowly injected also caused auricular distention. It is apparent that increasing degrees of distention would result if a series of injections were made of a preparation the circulation of which tends to weaken to a standstill, the maximum distention occurring at the complete cessation of the arterial circulation. In other words, by intrahepatic administration, at least part of the solution is apparently injected directly into the heart. As a matter of fact, air bubbles and colored solutions could be easily injected into the heart by the intrahepatic route. Colored solutions can be readily seen in the heart after its blood has been replaced by Ringer solution. That absorption from intrahepatic injection occurs there is no question, but we believe that the quick onset of effect is largely due to the portion of the solution that is injected directly into the heart.

Response of the heart.—Drugs intrahepatically administered produced variable results. This was especially true with heart stimulants such as caffeine and epinephrine. When the heart was still strong these drugs frequently produced a weaker contraction and an increased tone which could not be attributed to a toxic dose, for the same dose sometimes caused stimulation in the same frog. Stimulation usually occurred if the drug was administered when the heart had been weakened through prolonged contraction. The dose producing stimulation was usually ineffective on second administration. Ether and chloroform regularly brought about their characteristic depressant action. The method is indeed simple for demonstrating the action of these drugs upon the heart. However, it cannot be used to show the characteristic effect of caffeine and epinephrine, for Ringer or saline solution produced stimulation similar to that caused by those drugs. The stimulation in the one instance is sometimes indistinguishable from that in the other. With strophanthin the effect is gradually increasing tone to a standstill. This is similar to the effect of strophanthin as

described by Straub[2] in connection with his well-known preparation. The intrahepatic route demonstrates beautifully the antagonism of pilocarpine and atropine.

Intrahepatic administration vs. perfusion in situ.—The frog's heart responded regularly to the drugs that were used in these experiments when the heart was perfused with Ringer solution through the vena cava, as in Mines's method,[3] using a cannula with a "chimney" for introducing drugs to the heart. The insertion of the cannula in the vena cava in this method is more difficult than is the introduction of the needle in the intrahepatic; but, in testing the effects of drugs on the heart, the former method gives more satisfying results.

SUMMARY

1. Intrahepatic administration is at least partly intravenous or intracardiac injection.
2. The effects of caffeine and epinephrine on the frog's heart are variable when these drugs are administered by the intrahepatic route. They may cause depression or stimulation, depending upon the condition of the heart at the time of the injection.
3. Ringer and plain physiological salt solution injected intrahepatically produce cardiac stimulation which is sometimes indistinguishable from that caused by caffeine or epinephrine.
4. The intrahepatic administration is convenient for demonstrating the effects on the heart of cardiac depressants, the antagonism of atropine and pilocarpine, and the increased tone produced by digitalis.
5. Frog's heart responds more regularly to drugs administered by way of the vena cava, as in Mines's method, than by intrahepatic administration.

[2] Biochem. Zeitschr. 28 (1910) 392.
[3] Journ. Physiol. 46 (1913) 188.

ILLUSTRATIONS

[In all cases the tracings read from left to right: the upstrokes show systoles. The time, when indicated, is marked in seconds.]

Plate 1. Intrahepatic Administration

Figs. 1 and 2. Caffeine and epinephrine depression.
3 and 4. Caffeine and epinephrine stimulation.

Plate 2. Intrahepatic Administration

Fig. 1. Epinephrine at the beginning of the experiment.
2. Epinephrine on the same heart later.
3. First dose of epinephrine stimulant; second dose of the same size ineffective.

Plate 3. Intrahepatic Administration

Fig. 1. Ether.
2. Chloroform.

Plate 4. Intrahepatic Administration

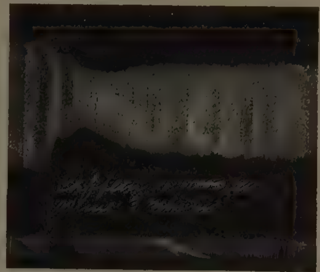
Figs. 1 and 2. Ringer solution.
3. Caffeine.

Plate 5

Fig. 1. Intrahepatic strophanthin.
2. Pilocarpine-atropine antagonism by intrahepatic injection.

Plate 6. Perfusion of Heart in Situ Through the Vena Cava with Drugs Administered by Way of the "Chimney" of the Cannula

Fig. 1. Chloroform.
2. Caffeine.
3. Epinephrine.



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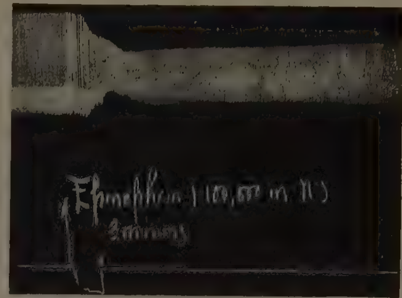

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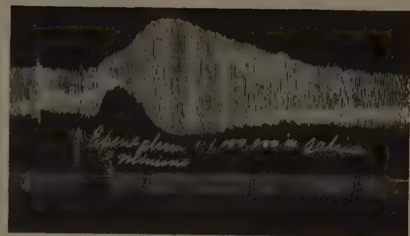
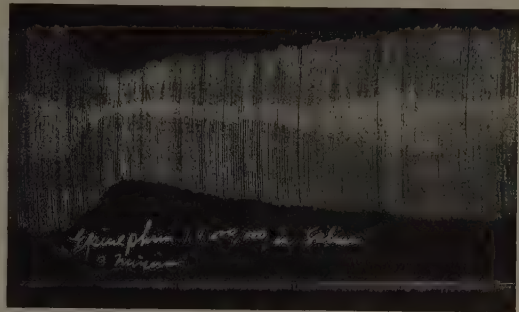


4

PLATE 1.



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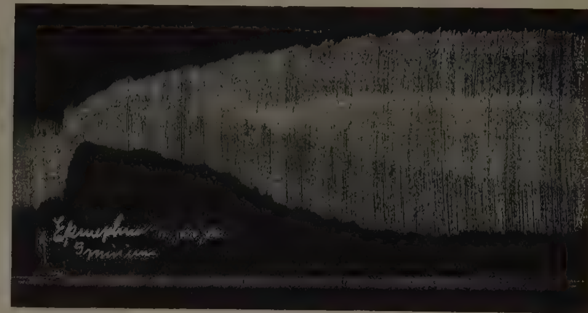

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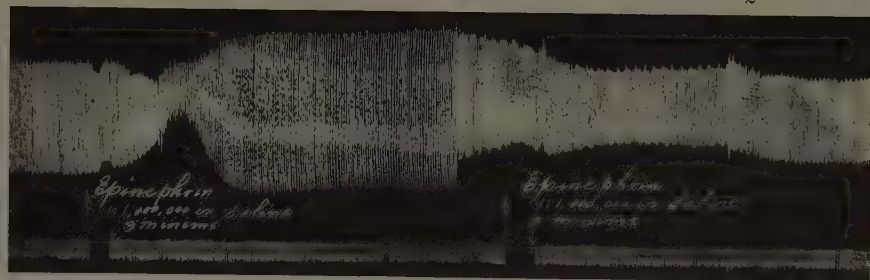

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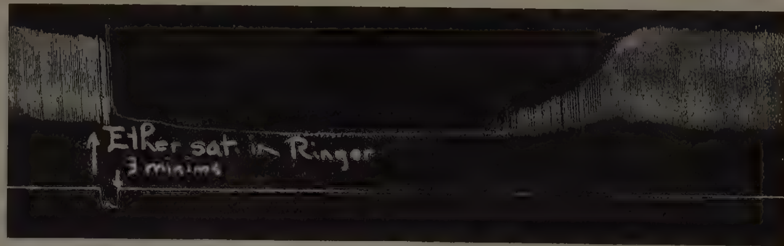

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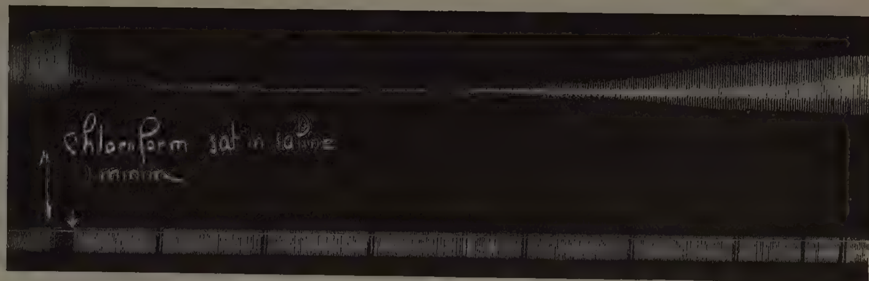

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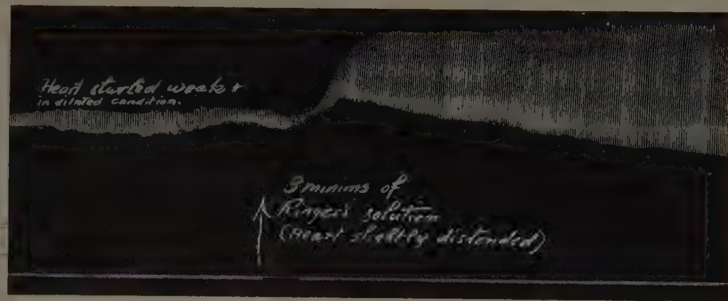
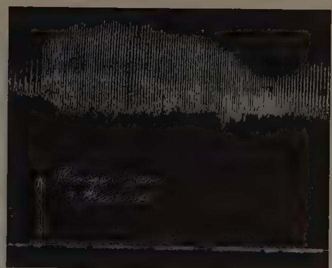
PLATE 3.


Heart started weak &
in dilated condition.
3 minims of
Ringer's solution
(Heart slightly distended)

1



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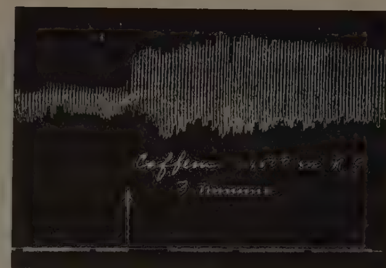

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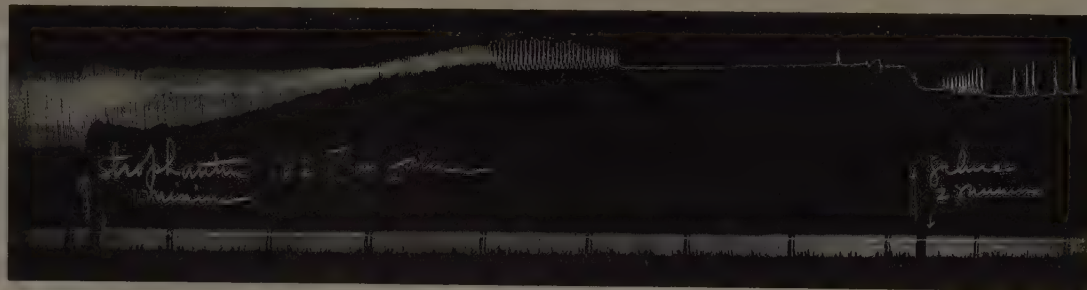

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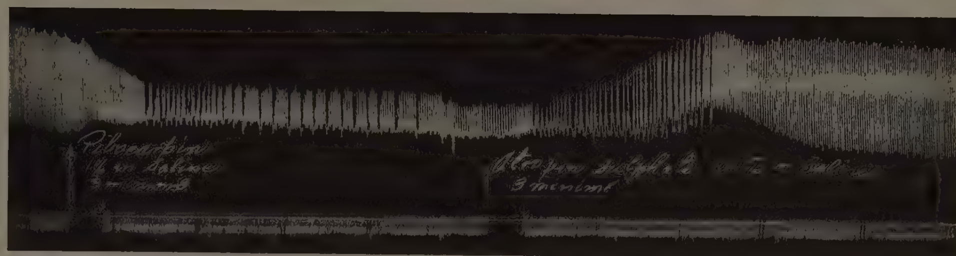

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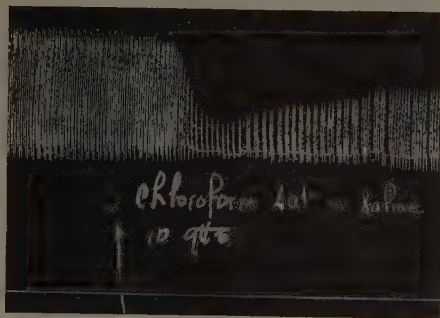

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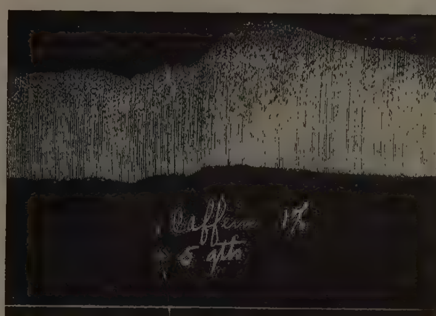

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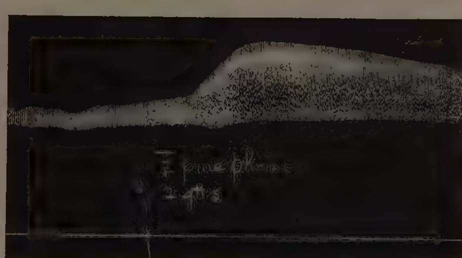

3

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